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SCIENCE

31 March 1961

Vol. 133, No. 3457

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

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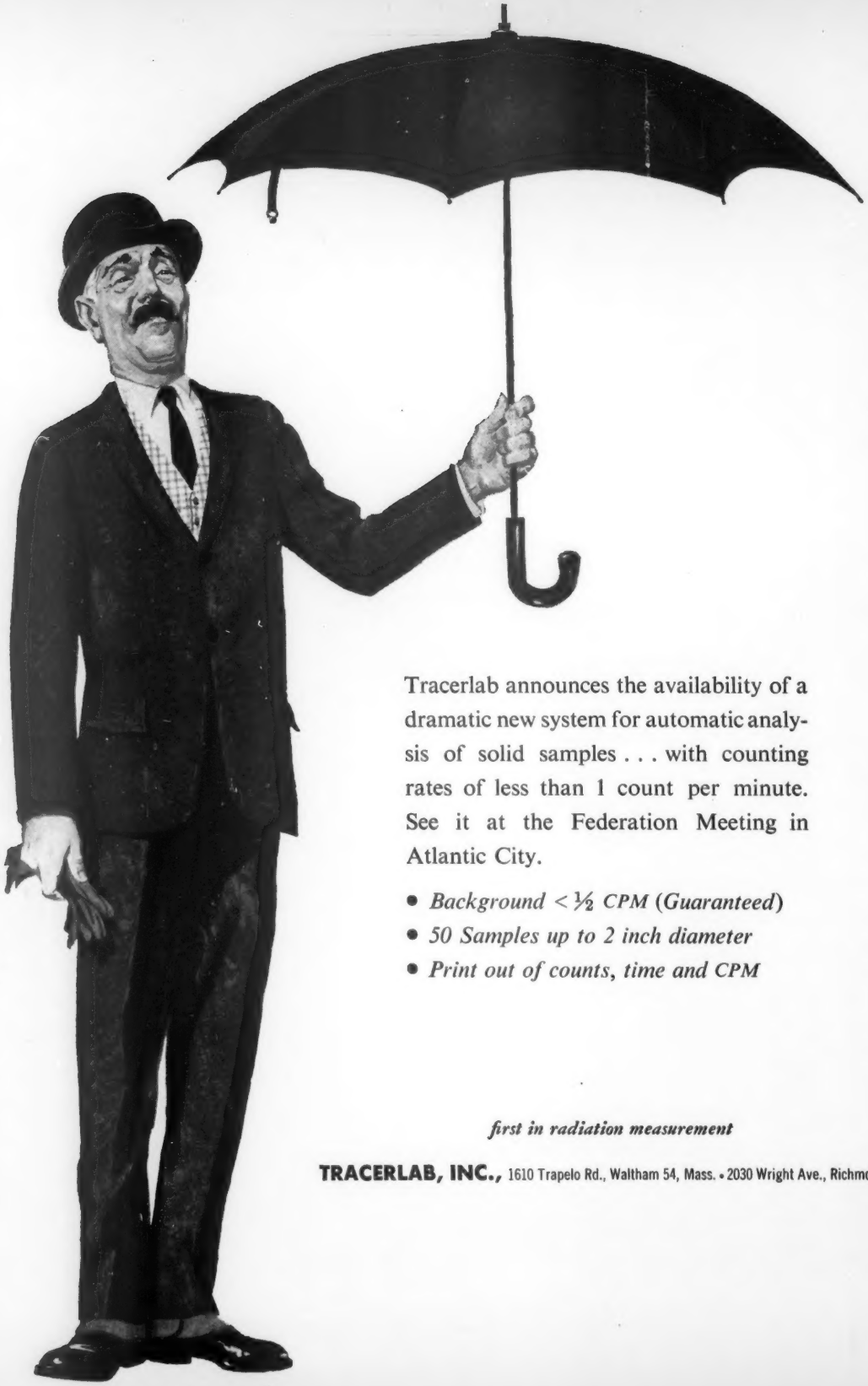

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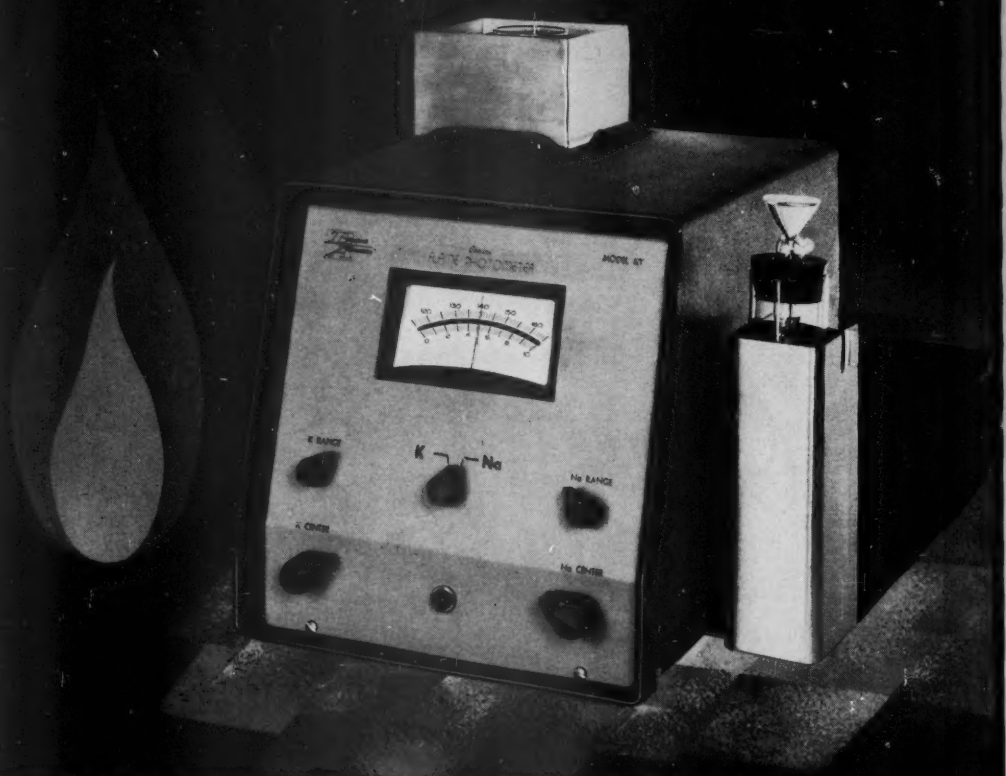

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Cover Vertical aerial photograph of a gravel mound and strip area near Shivtah. See page 979.

Letters

Retinal Flicker and Imprinting

A recent report by P. H. Gray [*Science* **132**, 1834 (1960)] contains the statement, "Moltz . . . has raised to the near status of law the conclusion that retinal flicker is an irreducible condition of imprinting." I have done nothing of the sort. Indeed, one entire section of my paper [*Psychol. Bull.* **57**, 291 (1960)] was devoted to showing that the imprinting response could be induced by stimuli other than those which produce retinal flicker. In several other sections as well I explicitly pointed out that any non-noxious stimulus (either visual or auditory) which dominates the sensory environment of the bird during an early period of development should subsequently evoke close following.

It appears that Gray's reference indicates either that he had examined my paper in a cursory manner and consequently had overlooked an important point or that he wished to construct a "straw man" which his experimental data could demolish.

HOWARD MOLTZ
Department of Psychology,
Brooklyn College, Brooklyn, New York

Early in his paper Moltz said: "Thus, imprinting will be defined as the procedure of visually presenting to an animal a large *moving* [italics mine] object during the first several hours of its life under conditions that insure that the object is not associated with such conventional reinforcing agents as food and water." He later departed from this definition to discuss auditory imprinting (irrelevant here) and the several statements by Menner (*1*) and James (*2*), the first stating the role of the pecten in enhancing the sensitivity of the avian retina to movement and the second concluding that retinal flicker was a critical factor in imprinting.

Since these were the exceptions Moltz made to the requirement of motion in his definition, and since he did not change the definition, it would be logical to think that he was taking a stand on this theoretical issue. According to his letter he was not. But contrary to the impression that could be gained from this letter, he did present his discussions in such a manner that if he *had* held retinal flicker to be the irreducible condition of imprinting, then nothing whatever in his paper would have required change. It would seem that he wrote the paper in such a manner that, if it were later incontestably proven that retinal flicker was necessary, it would not be possible to say Moltz had not championed the hypothesis.

This is a style of writing of which it is almost impossible to make a short and accurate statement on a contextual point. But I admit without reluctance that whatever my intentions, the peculiar wording of my statement about Moltz in my report did not come even close to what I should have said, which is essentially what I have said here. This was a failure in exposition for which I accept full censure. But it is the expository failure only which I admit; I do not find anything in Moltz's paper that can be interpreted in context as evidence that he foresaw the possibility of a positive preference for a motionless imprinting object not associated with a flicker-inducing light.

PHILIP HOWARD GRAY
Department of Psychology,
Montana State College, Bozeman

References and Notes

1. I am not familiar with Menner's article; H. James or Moltz should be consulted for the reference.
2. H. James, *Can. J. Psychol.* **13**, 59 (1959).

Stratospheric Fallout

There are several aspects of the recent article on the transport of artificial radioactivity, by Martell and Drevinsky [*Science* **132**, 1523 (1960)], to which I take exception. I should like to discuss one of them.

Martell and Drevinsky contend that the fallout in Milford Haven, Wales (presumably typical of the North Temperate Zone), from temperate-latitude stratospheric atomic clouds from Soviet testing in 1955 is about 10 times greater than fallout from equatorial low-stratospheric atomic clouds from the U.S. Redwing tests and almost 60 times greater than that from the equatorial high-stratospheric atomic clouds from the U.S. Castle tests, when values are normalized to an equivalent source strength. This remarkable difference in fallout from clouds in different stratospheric zones forms one of the cornerstones in their interpretation of weapon-test fallout.

It is my view, as expressed in the 1957 *Congressional Fallout Hearings* (p. 156), that the sense of the difference in amount of fallout, relative to source strength, from temperate and from equatorial stratospheric injections is correct. However, I think that the numbers 10 and 60 should be reduced to something like 1.2 and 5 or less, respectively.

The bases for my differences with Martell and Drevinsky are as follows:

1) Martell and Drevinsky confuse fallout in different seasons, despite the seasonal trends in their own as well as in other data. Thus, they should correct upward by a factor of 2.5 their figure for fallout in August–December from the Redwing tests to make it comparable to the figure for fallout in February-June 1956 from Soviet tests in the fall of 1955; the factor 2.5 is based on their own finding for tungsten-185 fallout from the U.S. Hardtack equatorial atomic tests (see their Fig. 5). This latter test series was similar to the Redwing atomic tests.

2) If one limits oneself to the same period (February–June) for which the fallout from the Soviet tests of 1955 was computed, then the normalized value for fallout from the U.S. Castle atomic clouds is increased by a factor of 2.5 over the value given by Martell and Drevinsky. Further, if all the fallout during the period February–June 1955 is assigned to Castle, then the factor of increase becomes 3. Whether one attributes only part of the February–June 1955 fallout or all of it to the Castle tests depends on whether one assigns any of the fallout in this interval to the fall 1954 Soviet Temperate Zone tests on the basis of isotope-ratio data. Martell and Drevinsky assume that debris from the fall 1954 tests entered the stratosphere. But information sources with which I am familiar do not assign any radioactive debris from these tests to the stratosphere; thus, essentially all of the February–June 1955 fallout would be from Castle. The isotope data leading to the contrary viewpoint are confused by fallout data from the Nevada Teapot atomic tests in progress from February to May 1955.

3) The Department of Defense [A. K. Stebbins, *DASA No. 532B* (1960)] has estimated an amount of stratospheric fallout from the Castle tests less by a factor of about 2 than was assumed by Martell and Drevinsky. If the Department of Defense estimate is correct, this would increase the normalized value for fallout by an additional factor of 2. However, the uncertainty about residual stratospheric debris is such that the validity of this additional correction to the normalized value for fallout from the Castle tests must be questioned.

4) The fallout from the Soviet autumn 1955 test series in the period February–June 1956 selected by Martell and Drevinsky was only 25 percent or less of the total fallout for that period. This conclusion derives from arguments used by them, except that

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only the November 1955 test of the series can be treated as a source of stratospheric fallout. None of the other three shots of the Soviet autumn 1955 tests were announced by the U.S. Atomic Energy Commission as having been large. Actually, Martell and Drevinsky state that about 50 percent of the fallout was from the Soviet 1955 testing (a figure derived, I presume, by using the mid-point for the entire September–November 1955 series), but they employ 100 percent of the fallout in their arithmetic. Thus, their normalized value for fallout from the Soviet 1955 tests should be reduced by a factor of 4. These differences are illustrated in Table 1.

Martell and Drevinsky gave a ratio of fallout from Soviet 1955 tests to fallout from Redwing as 10.0; my figure is 1.1. They give a ratio of 57 for the Soviet 1955 and the Castle tests; my figure is 4.8 (2.4?).

It should be noted that various periods up to 20 months were used in Martell and Drevinsky's computations while I used only the first February–June period after the test series, or corrected to this period in the case of Redwing.

The determination of fallout per unit source strength is subject to many uncertainties. I feel that one is on especially weak ground in making any such specific assignment of fallout to Redwing as Martell and Drevinsky suggest.

There are two additional test series not included in Table 1 which may be cited in considering the two sets of figures. They are the Soviet October 1958 series in the Arctic, whose fallout may behave like that of the Soviet 1955 test series, and the Hardtack test series, which, as indicated above, may be similar to the Redwing test series. The analysis is derived from Fig. 5 and Table 1 in the article by Martell and Drevinsky. The results, again limited to the first February–June period after the series, are as follows: Hardtack, 0.9 $\mu\mu$c/lit. per megaton; Soviet tests of October 1958, 1.2 to 1.5 $\mu\mu$c/lit. per megaton. The ratio of normalized values for fallout from arctic tests to values for fallout from equatorial tests is, then, 1.3 to 1.7, a value similar to my value of 1.1 for the ratio of fallout from Soviet 1955 tests to fallout from Redwing but much smaller than the value 10 given by Martell and Drevinsky.

I should point out that the differences in fallout relative to source strength from equatorial (U.S. Pacific) and temperate or arctic (U.S.S.R.) sources of stratospheric atomic clouds probably have more significance for the meteorology of stratospheric motions than for evaluating health hazards.

Table 1. Normalized values for fallout per unit source strength (in $\mu\mu$c of Sr^{90} per liter of rainwater at Milford Haven, Wales, per megaton).

Castle (equatorial, high altitude)	Redwing (equatorial, low altitude)	Soviet 1955 (temperate)
	Martell and Drevinsky	
0.07	0.4	4.0
	Machta	
0.22 (0.44?)	0.9	1.0

If Martell and Drevinsky concur in the foregoing analysis, I wonder if they would still claim that "fallout from equatorial tests [is] substantially less significant per test unit than fallout from tests in other latitudes," as they argue in the concluding sentence of their article.

LESTER MACHTA
Office of Meteorological Research, U.S. Department of Commerce, Washington, D.C.

Machta has gone to great lengths in an attempt to show that we have overstated the difference in Milford Haven fallout per unit source strength for the 1955 Soviet tests as compared to the equatorial Castle and Redwing tests by an order of magnitude. In so doing, he has changed the basis of comparison and uses arguments of questionable merit. Since our own interpretation of the data is adequately discussed in our article, we will restrict our attention to Machta's main points.

Machta first raises the normalized fallout rates for the Castle and Redwing tests by a factor of 2.5, apparently in order to eliminate seasonal effects and to compare fallout rates at the time of the spring peak. This procedure appears to be pointless. Since stratospheric storage times, regardless of source location, are short as compared to the half-lives of Sr^{90} and Cs^{137}, the significance of relative fallout rates is associated primarily with the short-lived radioisotopes in fallout. For this reason, we chose to compare fallout rates at corresponding early times after each test, during periods for which isotope-ratio data allowed approximate assessment of origin.

If one wished to compare the relative Sr^{90} fallout rates from various sources in a given season, he should direct his attention to isotope-ratio and concentration data in that season at the point of interest. Machta's arbitrary use of seasonal factors to construct data for one season from observations in another is hardly an acceptable scientific procedure. Furthermore, his application of a seasonal factor observed for one location and test series to another location, other years, and other tests of radically different cloud height distribution involves an unreasonable degree of generalization from a limited set of observations. The same limitations apply to his drawing of a parallel between the October 1958 and the fall 1955 Soviet tests.

Machta next reduces the fallout contribution of the 1955 Soviet tests by a factor of 2 by assigning all of the contribution from that test series to the high-yield 23 November shot alone. Other shots of that series are reported to have been fired on 4 August, 24 September, and 10 November. In the absence of reliable and complete shot-yield and cloud-height data for that test series, we preferred to take the mid-point of the test period as the mean production date and accept an uncertainty which includes Machta's assignment as a lower limit. It should be pointed out that clouds from surface and air shots of about 100-kiloton yield rise well into the stratosphere at Soviet test latitudes [for example, see W. W. Kellogg, *U.S. Atomic Energy Comm. Rept. No. AECU 3403* (14 June 1956)]. Machta has yet to prove that the only spring 1956 fallout at Milford Haven from the 1955 Soviet test series came from the 23 November shot.

He further reduces the 1955 Soviet test contribution by an additional factor of 2 by using the exact fraction indicated by the Sr^{89}/Sr^{90} ratio. However, for the post-Castle period, he disregards the isotope-ratio data and assigns all Sr^{90} fallout to Castle. He invokes tropospheric fallout from the February–May 1955 Nevada Teapot tests to explain the Sr^{89}/Sr^{90} ratio data at Milford Haven for that period. Machta's interpretation affords no explanation of the Sr^{89}/Sr^{90} value of 21.9 for the period 11–31 January 1955. Machta apparently has missed the significance of our Ba^{140}/Sr^{90} results, which indicate the stratospheric origin of most short-lived radioisotopes in long-range fallout.

In view of the marked differences in assumptions and basis of comparison, to compare Machta's conclusions with our own is meaningless. Nothing of Machta's argument would provide an acceptable basis for altering our interpretation of the Milford Haven data beyond our stated uncertainties. In our interpretation of the isotope-ratio data, we have tried to be as objective as possible and have studiously avoided generalizing too broadly from one set of fallout observations to other tests, other years, and other sites.

E. A. MARTELL
P. J. DREVINSKY
Air Force Cambridge Research Laboratories, Air Force Research Division, Bedford, Massachusetts

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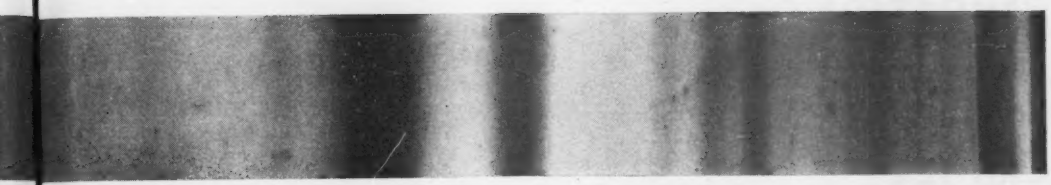

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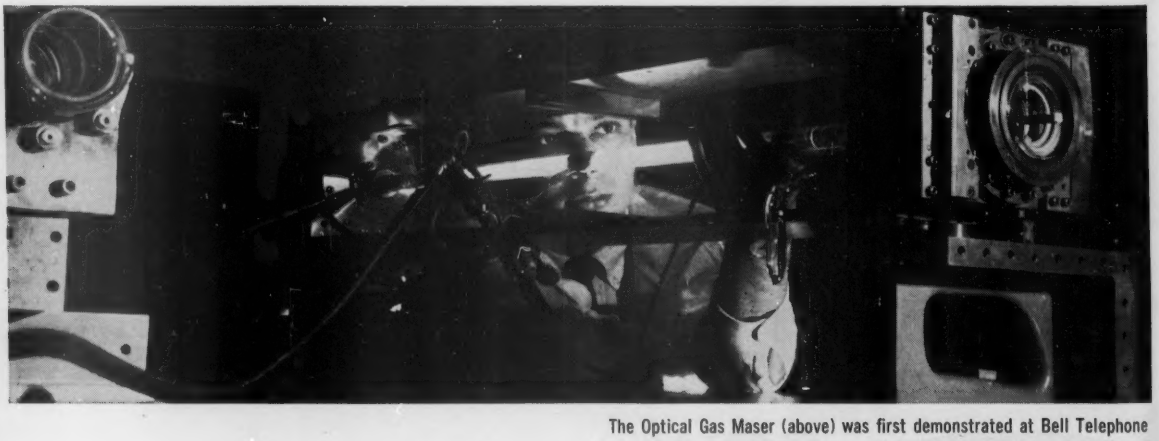

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The Peace Corps, which was established by executive order on 1 March, is based upon the bold premise that Americans are willing to sacrifice personal comfort and financial advantages to be of service to other nations.

The response to the program augurs well for its future. Apparently there will be no shortage of able volunteers in some of the major fields of interest. Some 800 to 1500 letters of inquiry pour in daily at the Peace Corps' improvised headquarters in Washington. A random sample of 300 showed a notably low number from the illiterate and unbalanced, and a remarkably high number from the apparently competent and well qualified. The greatest number of letters came from graduate and undergraduate students, but there were many from nurses and teachers, and a sprinkling from M.D.'s, Ph.D.'s, lawyers, engineers, and construction workers. It seems probable that projects calling for teachers and nurses can be readily staffed, but others—notably those that call for engineers, architects, and construction workers—may offer major difficulties.

The detailed plans are not yet clearly drawn, but the staff is adhering to certain general principles as guidelines. Volunteers will get allowances sufficient to maintain them in good health but not large enough to enable them to live at a conspicuously higher standard than their counterparts abroad. The volunteers will work side by side with the residents—they will be a part of the community. Projects will be initiated only at the wish of the foreign governments and upon approval by our government. Only after a project has been agreed upon will the Peace Corps select volunteers and arrange a training program for that particular mission.

Success will hinge upon how well these principles can be put into practice, and especially upon the skill and imagination that are brought into play in the selection and training of the volunteers. It is encouraging to note that people experienced in education and the social sciences are being drawn into these phases of the program; Arthur S. Adams, formerly president of the American Council on Education, is in charge of training, and Nicholas Hobbs, a psychologist who was formerly chairman of the Division of Human Development and Guidance at Peabody College, is in charge of selection. Fortunately, these men and their staffs can draw upon the experience gained by the International Cooperation Administration (of which the Peace Corps is a part) and by several voluntary medical and missionary organizations in preparing people for service abroad.

The Peace Corps is off to a good and enthusiastic start. The hazards are great, but if the program is successful the results will justify the risks. Success will bring genuine help to the developing nations, the austerity of the program will help dispel the distorted view that the American people are grossly materialistic and self-regarding, and the interchange between the volunteers and their foreign co-workers, as they work together on specific problems, will effect great gains in mutual understanding and respect.—G.DuS.

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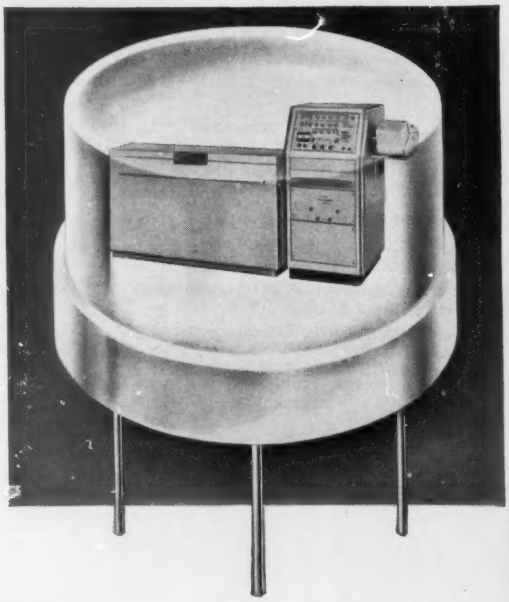

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31 March 1961, Volume 133, Number 3457 SCIENCE

Ancient Agriculture in the Negev

Archeological studies and experimental farms show how agriculture was possible in Israel's famous desert.

M. Evenari, L. Shanan, N. Tadmor, Y. Aharoni

The Negev desert of Israel, with its numerous, clearly visible traces of ancient civilizations dating back at least four to five thousand years, has attracted the attention of many scientists. Since Palmer (*1*) in 1871 described the general character of these civilizations as well as the intriguing agricultural remnants that he observed in the area, the Negev has become a field of research for many phases of science.

We have been working as a team in the Negev desert for five years with the specific aim of solving the enigma of the once flourishing agricultural civilizations in a now barren desert. This team covers the fields of botany, archeology, ecology, hydrology, and water engineering, and this combination of experience and interests enabled us to correlate widely differing fields of observation. In this article we present some of our conclusions as to how the ancient civilizations maintained a thriving agriculture in the desert and also indicate their possible application in the future.

Description of the area. The Negev is shaped like a triangle (Fig. 1). Its base line stretches in the north from an imaginary line drawn from Gaza on the Mediterranean Sea, through Beer Sheva, to Ein Gedi on the Dead Sea. Its two sides stretch from Gaza and from Ein Gedi down to Eilat on the Gulf of Aqaba. The 12,500 square kilometers of the Negev can be divided into the six following subregions: (i) the coastal strip; (ii) the lowlands and foothills; (iii) the central highlands; (iv) the sedimentary southern Negev, mostly consisting of rolling gravel plains; (v) the crystalline southern Negev representing the northeast corner of crystalline Sinai; and (vi) the Wadi Araba depression.

The physiographic and climatic conditions vary from subregion to subregion, and the various civilizations naturally adapted their agricultural projects to these differing features. The densest settled areas have been discovered in the lowlands and the highlands, and since most of our investigations have been concentrated in these subregions, we will describe them briefly.

The lowlands and foothills. This subregion is a strip about 10 to 25 kilometers wide, bounded by the coastal region on the west and the central highlands on the east and covering about 150,000 hectares. The morphological structure is made up mostly of Eocene limestone hills separating wide rolling plains, with the elevations ranging from 200 to 450 meters above sea level. This area contains the ancient towns of Nessanah, Sbeita, Ruheibeh, and Khalassah. A number of large wadis, whose sources are in the highlands, cut through the plains and drain towards the Mediterranean Sea. The hillsides are generally covered with a very shallow, gravelly, saline soil possessing an immature profile. The flora is dominated by the Zygophylletum dumosi association (*2*).

On the other hand, the Quaternary aeolian-fluviatile loess soils of the plains are relatively deep (2 to 3 meters) and only slightly saline. The Haloxylonetum articulati association is typical for these areas.

The highlands. This subregion covers some 200,000 hectares and contains the ancient towns of Mamshit (Kurnub) and Avdat (Abde). It is composed of a series of parallel anticlines, and the elevations vary between 450 and 1,000 meters above sea level. The anticlines are composed of Cenomanian Turonian limestones and cherts.

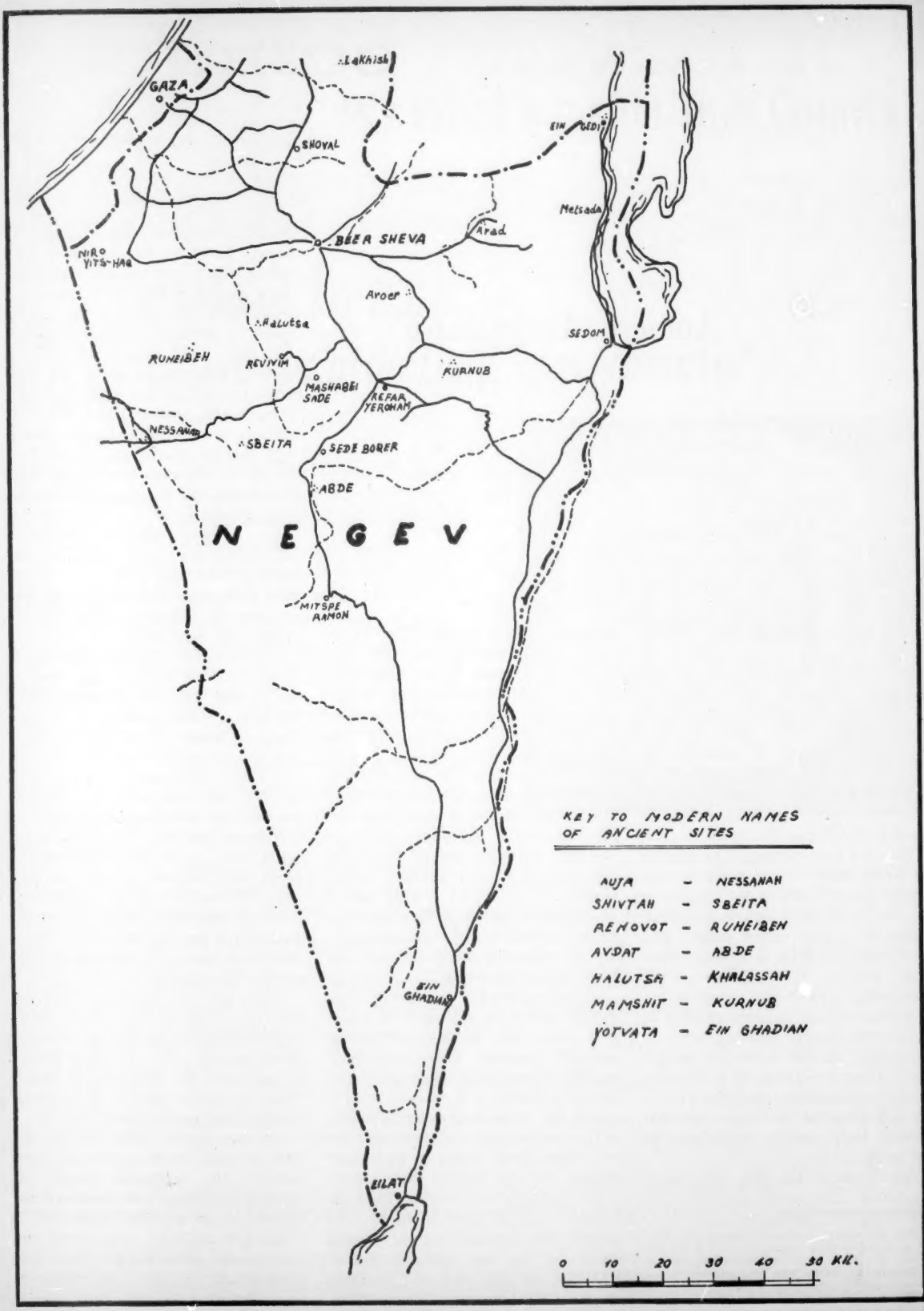
Between the high ridges, the main wadis drain to the Mediterranean and Dead seas. Adjacent to the wadis lie relatively narrow alluvial plains, and near the watershed divides where the wadis have not cut down to a stable base level, there are a number of expansive plains.

There are two principal plant habitats common to the area. On the rocky slopes (80 to 90 percent of the area) where the soil cover is shallow, gravelly, and saline, the Artemisietum herbae albae association prevails with transitions to the Zygophylletum dumosi.

On the loessian plains and in the wadi bottoms where loess has accumulated, the vegetation consists of sparsely distributed low shrubs of the Haloxylonetum articulati association.

Rainfall conditions. The rainfall records of our area have not been kept systematically for any long period of time. But even the few short records

Dr. Evenari is professor of botany at the Hebrew University, Jerusalem, Israel; Mr. Shanan is a hydrological engineer in Tel Aviv; Dr. Tadmor is a plant ecologist with the Ministry of Agriculture of Israel; and Dr. Aharoni is an instructor in the department of archeology of the Hebrew University, Jerusalem.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REVIVIM
KURNUB
MASHABEI SADE
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SEDE BORER
ABDE
NEGEV
MITSPE RAMON
EIN GHADIAN
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KEY TO MODERN NAMES OF ANCIENT SITES
AUJA - NESSANAH
SHIVTAH - SBEITA
RE HOVOT - RUHEIBEH
AVDAT - ABDE
HALUTSA - KHALASSAH
MAMSHIT - KURNUB
YOTVATA - EIN GHADIAN
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Fig. 1 (left). Map of the Negev. The key gives modern names at left, ancient names at right.

that have been published show that we deal here with that typical pattern of rainfall which is so characteristic for all deserts.

A study of Table 1 shows that the variations between maximum and minimum annual amounts of precipitation are large and that most of the rain falls in quick short showers of less than 10 millimeters. The difference between the average and median annual values should be noted, as, for agriculture, the median and not the average is significant.

The average number of rainy days with daily totals of precipitation of 0 to 3, 3 to 10, and more than 10 millimeters is another important figure, as it touches on the problem of the minimum "effective" rainfall (*3*).

Agricultural history of the Negev. The Northern Negev was, in historical times, first settled during the chalcolithic period (4th millennium B.C.). But up to now, no trace of this period has been found in the Central and Southern Negev (*4*).

During Middle Bronze I (21 to 19th century B.C.), the Negev was quite densely populated. The next period of sedentary settlement dates from the end of the 10th century B.C. to the beginning of the 6th—that is, the period of the Judaean Kingdom (Israelite periods II–III, or Iron Age II). However, the time between about 200 B.C. and A.D. 630 represents the longest and most flourishing period of almost continuous settlement in the Negev. During this time, the Nabataeans and Romans (about 200 B.C. to A.D. 330) and the Byzantines (A.D. 330 to 630) ruled the area (*5*). After the Arab conquest, from the 7th century A.D. up to our time, the Negev was occupied only by nomadic Bedouins (*6*).

As far as the *agricultural* history of the Negev is concerned, our own surveys and excavations of Israelite farms and settlements (*7*) and the surveys of Glueck (*8*) have shown that the Israelite period III settlers already carried out desert agriculture based on flood-water irrigation. We may men-

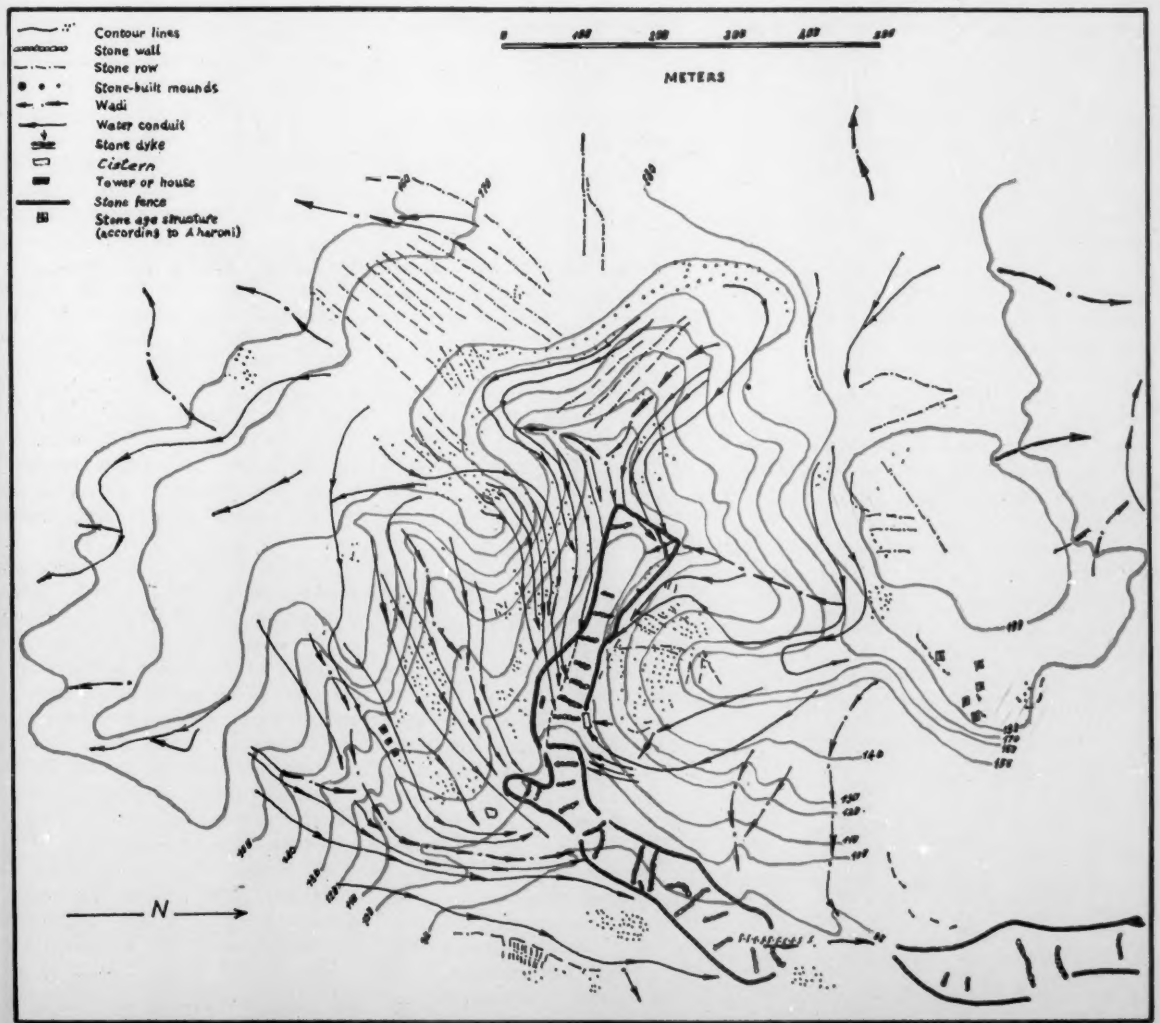


Fig. 2. Map of a runoff farm area near Avdat. Note the conduits and stone mounds.

Fig. 3. An oblique aerial photograph showing a number of ancient runoff farms near Shivtah.

tion that this is corroborated by the Bible (II Chron. 26:10), where it says of King Uzziah, who ruled the Negev down to Elath, "also he built towers in the desert, and hewed out many cisterns . . . for he loved the land." But it may even be that the Middle Bronze I people practiced run-off desert agriculture, as the Negev is full of their settlements (*9*). During the Nabataean-Roman-Byzantine period, desert agriculture reached its peak of development. After the Arab conquest, the ancient desert agriculture slowly disintegrated, and the Bedouins of the area at best merely utilize dilapidating old systems for patch cultivation.

Outside of the Negev of Israel, ancient desert agriculture is known from the following areas: (i) North Africa [Algeria, Tunisia, Lybia (*10–14*)], Syria (*15*), and Transjordan (*16*), where it flourished under Roman domination; (ii) Southern Arabia (*17*); (iii) North America, where it was practiced and is being practiced by the Indians (*18*); and (iv) South America, where it was carried out by the pre-Hispanic civilizations (*19*).

Table 1. Rainfall data (in millimeters).

Item	Station		
	Aslug	Auja	Mamshit
No. of years of record	13	14	9
Highest total annual recorded	170	285	171
Lowest total annual recorded	52	25	58
Average annual	100	89	98
Median annual	86	65	80
Av. No. of days per year with total of 0–3 mm	9	5	5
Av. No. of days per year with total of 3–10 mm	7	3	6
Av. No. of days per year with total of more than 10 mm	2	2	2

Ancient desert techniques of water utilization for agriculture. There are relatively large areas in the desert where the soils are suitable for cultivation and the only requirement is water. This is true for most of the not too steep wadis, the flood plains, and the depressions where loess soils have accumulated to a depth of 1 to 2 meters. The key to establishing sedentary agriculture in a desert is, therefore, maximum utilization of the meager rainfall.

For this reason, our work has been concentrated on studying the techniques used by the ancient civilizations to collect and exploit the meager water resources of the area. The techniques that we have so far studied in detail, and that are presented in this article, can be divided into the three following main categories: (i) exploitation of runoff from small watersheds (up to 100 hectares in size); (ii) exploitation of runoff from large watersheds (up to 10,000 hectares in size); and (iii) chain-well systems.

Exploitation of Runoff from Small Watersheds

The exploitation of runoff from small watersheds (*20*) is by far the most interesting of all the methods utilized by the ancients, since it made possible the very intensive development of the area.

The basic principle of the method was simple but nevertheless required a good understanding of the sciences of hydrology, soils, and meteorology. Table 1 shows that most of the rainfall in the desert falls in relatively light showers—3 to 10 millimeters at a time. These meager amounts of rainfall are generally regarded as ineffective—that is, they wet a very shallow depth of soil, which dries by evaporation before plants can utilize the moisture. However, the loess soils of the area have a characteristic of forming a crust when wet. This crustal formation was studied by D. Hillel (*21*), who has shown it to be an intrinsic feature of the Negev loess soil: the aggregated structure of the soil surface is destroyed by a wetting or slaking process. The crust decreases the water-intake rate of the soil and so increases the rate of runoff.

This phenomenon was observed by the ancients and exploited to the maximum. The loessial hillsides, which became more or less impermeable after wetting, were utilized as catchment basins to produce runoff for subsequent utilization in nearby fields. The desert farmer's aim was to prevent a penetration of rain on the slopes and so produce maximum runoff, whereas the farmer in more humid lands aims to soak all of the rain into the soil and so minimize runoff. The desert farmer directed the runoff from a large area on the slope to a small cultivated area in the bottomlands, and in this way he was able to collect sufficient water to ensure a crop even under adverse desert conditions.

This ingenious type of runoff agriculture we define as runoff farming, and the cultivated units to which it was related we call runoff farms.

Each runoff farm consisted of the farm area proper, containing the cultivated fields, and the surrounding catchment basin. The cultivated area

Fig. 4 (right). A vertical aerial photograph of a gravel mound and strip area near Shivtah.

Fig. 5. A field of gravel mounds near Shivtah.

was subdivided into terraces by low terrace walls. The function of the terrace walls was to retain the flood water on the field, where it could soak into the soil and be stored for subsequent use by the crops. A number of terraced fields were surrounded by a stone wall, constituting a distinct unit (*22*). Within the area bounded by the wall there is very often a farmhouse or a watchtower. The hillsides surrounding the farm served as a catchment area from which water conduits channeled the runoff water onto the fields. Once the water was inside the farm, drop structures, ditches, and dividing boxes gave the farmer complete mastery over the distribution of the water. Figures 2 and 3 illustrate this very well. Figure 2 represents a system near Avdat. The whole catchment area comprises about 70 hectares and is artificially divided into a number of smaller catchment basins by several conduits, each leading to a specific terraced field in the narrow valley. Some of the conduits begin high on the plateau and collect runoff from there.

The 70 hectares of watershed of this system supplied water to about 2.2 hectares of cultivated land.

Figure 3 represents a number of runoff farms in the Shivtah area. Each farm received its runoff water from its own small wadi and from the many conduits which collected water from the small catchment basins on the hillside adjoining each farm.

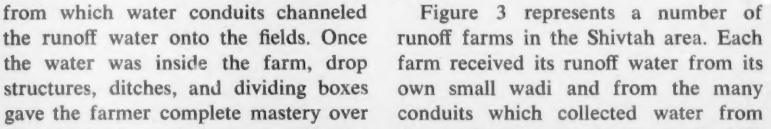


Fig. 6. A field of gravel strips near Shivtah.

About 100 runoff farms, together with their catchment basins, have been studied in detail.

Each farm unit formed an entity comprising a catchment basin and cultivated land. The larger the catchment basin, the more the water yield and the greater the corresponding area that could be irrigated. The ancient farmers often extended their water-collecting conduits to the plateaus high above their fields in order to increase the available water supply, and sometimes conduits were led around the hillsides so as to increase artificially the natural drainage area of the runoff farm. These catchments were therefore "water rights," and each runoff farm possessed a water right on a definite portion of the slope. These water rights, which generally vary in size from 10 to 100 hectares, were no less important a part of the runoff farm than the cultivated land itself. The man who owned water rights on the slopes could always build himself a farm, but not vice versa.

The farm land and its catchment on the slope are thus a mutually balanced system of land and water. All the precious water collected from the slope was used. If there was any surplus water on the farm, the cultivated area was extended by adding a new terrace downstream. It was probably only in exceptionally rainy years that surplus water passed over the lowest spillway of a runoff farm and flowed to the next terrace. On the other hand, permanently "dry" terraces were of no avail, and the farmer only built a new terrace if his expectations of getting it wet were reasonably good. Catchment and cultivated area are thus seen as a clearly defined unit—an integral part of an over-all plan of watershed subdivision.

The conduits generally collected water from a relatively small area, sometimes as small as 0.1 to 0.3 hectare and generally not larger than 1.0 to 1.5 hectares. The result was that the overall runoff was always divided into small streams of water, preventing the occurrence of large flash floods. Such controlled flows are suited to the dry stone structures of the ancients; moreover, only such small flows could be handled by a farmer and allow him to control the flow during the flood period. Flows from even 1 hectare of catchment might reach a high peak intensity for short periods. For example, with a peak rain intensity of 30 millimeters per

hour and a 60-percent (an extreme figure) runoff for a short period during a single rain storm, 1 hectare of slope might yield a peak flow of 180 cubic meters per hour, if only for a few minutes. This requires a ditch with a cross section of 0.05 to 0.10 square meter (depending on gradient), a requirement which readily fits observed ditch dimensions.

The farmer could therefore not allow the waters to collect from a larger area, as the resulting peak flow would have been unmanageable and would have destroyed his terrace structures. The over-all runoff was thus effectively broken up into small streams.

The crucial question that arises is the amount of runoff the ancient farmers received per unit area. Actual field measurements of runoff already initiated on our two reconstructed farms, discussed below, will have to be made for at least 10 years before a reliable estimate can be made. We approached this question indirectly by analyzing the ratio

$$R = \frac{\text{area of catchment basin of ancient farm}}{\text{area of cultivated area of ancient farm}}$$

About 100 farms in the Avdat, Shivtah, and Auja areas show that this ratio varies between 17:1 and 30:1, with an average value of about 20:1. This means that between 20 and 30 hectares of catchment area were needed to irrigate 1 hectare of cultivated field. Present-day agricultural experience has shown that flow of at least 3000 to 4000 cubic meters per hectare has to be applied as supplementary irrigation in order to insure any crop in this desert area. (Each 1000 cubic meters of water per hectare will wet about a meter of soil depth.) Taking these figures as a basis, we calculated that if 20 hectares on the slopes supplied the 3000 to 4000 cubic meters of water, every hectare of catchment supplied 150 to 200 cubic meters of water per year. If each hectare of catchment supplies 150 to 200 cubic meters of water (which is equivalent to 15 to 20 millimeters of rainfall), we can safely conclude that the coefficient of runoff was at least 15 to 20 percent of the total annual precipitation.

These runoff farms formed an important part of the desert settlements throughout the ages, and primitive but nevertheless well-defined runoff farms have been found dating from the 10th to the 8th centuries B.C. (*7*). This form of intensive sedentary agriculture was probably continuous throughout all the civilizations, reaching its peak in the Roman-Byzantine era. Interesting and conspicuous features related to the runoff farms are the gravel mounds and gravel strips (see Figs. 4–6) and stone mounds and strips. These man-made structures cover thousands of acres and are common in the vicinity of the ancient cities of Avdat and Shivtah. The gravel mounds are low heaps of gravel artificially arranged in long rows with a more or less uniform distance between the mounds. The strips are of the same material. Mounds and strips are often intermingled and form all kinds of intricate patterns. They are only found on hammadas (*23*) covered by small gravel and are made by raking together the gravel.

The stone mounds and strips are built of much bigger stone fragments and are typical for those areas where for geological reasons the slopes are covered with big stone fragments and not with gravel. Gravel mounds, gravel strips, stone mounds, and stone strips are found exclusively on slopes leading to farms or cisterns (*24*, *25*).

Since Palmer (*1*) first discovered these structures, all authors dealing with them agree that they are related to agriculture, and the following theories have been proposed concerning their function.

1) Palmer was told by his Bedouins that the arabic name for these structures is *teleilât el 'anab* or *rujum el Kurum*—that is, "grape mounds" or "vineyard heaps." "These sunny slopes," he concluded, "would have been admirably adapted to the growth of grapes and the black flint surface would radiate the solar heat, while these little mounds would allow vines to trail along them and would still keep the clusters off the ground."

A number of authors (*26*), and lately Mayerson (*27*), follow Palmer's theory. In our opinion, the slopes can never have been used for growing grapes because there is either no soil at all or only a very shallow superficial soil cover which is highly saline (2 to 5 percent total soluble salt). The naturally occurring plant associations on these slopes indicate the most difficult growing conditions for plants. As we have shown, the amount of rain water these slopes receive is insufficient for growing grapes, and since the ancient farmers never used all the good loess soils available, there was no reason for them to cultivate the worst soil to be found in all the desert (*28*).

2) Some authors (*10*, *29*, *30*) believe that the function of the mounds was to condense dew. But experiments have shown that no dew can be collected in the mounds and that the water relations of the soil below the mounds do not differ from those of the surrounding soil (*31*).

3) Kedar (*24*, *32*) put forward the theory that the main function of the mounds was to increase soil erosion from the slopes in order to accumulate more soil in the wadi bottoms ("accelerated erosion"), as in his opinion the main hindrance to agriculture was lack of suitable soil and not lack of water. There are a number of objections to this theory. First, there is and was plenty of good loess soil in the valley bottoms and flood plains close to the ancient agricultural systems. As today, lack of water and not lack of cultivable soil was the main problem of the ancients. It is hard to believe that the ancients, who knew so much about water spreading, would have endangered their elaborate systems by intentionally introducing silting, the arch enemy of any water-spreading system. Furthermore, some of the gravel-mound areas lead to water cisterns, where the accumulation of silt by erosion is most undesirable. The gradient of some of the collecting ditches varies from 0.5 to 1 percent. If they had been designed to carry silt, a much steeper gradient would have been necessary. But the main objection lies in a simple calculation. According to Kedar's experimental figures (*33*), an ancient farmer would have had to wait patiently for about 20 to 50 years after building an elaborate structure in the wadi before sufficient soil had accumulated to justify the planting of a crop (*34*).

4) We have proposed (*31*) that mounds and strips were established in order to increase the amount of surface runoff and gain more water for the fields below (*35*). Hillel (*21*) has shown that the infiltration capacity of the prevailing soil of the region decreases markedly with the formation of a characteristic surface crust through the physical slaking of the upper layer during the wetting-drying cycle. This

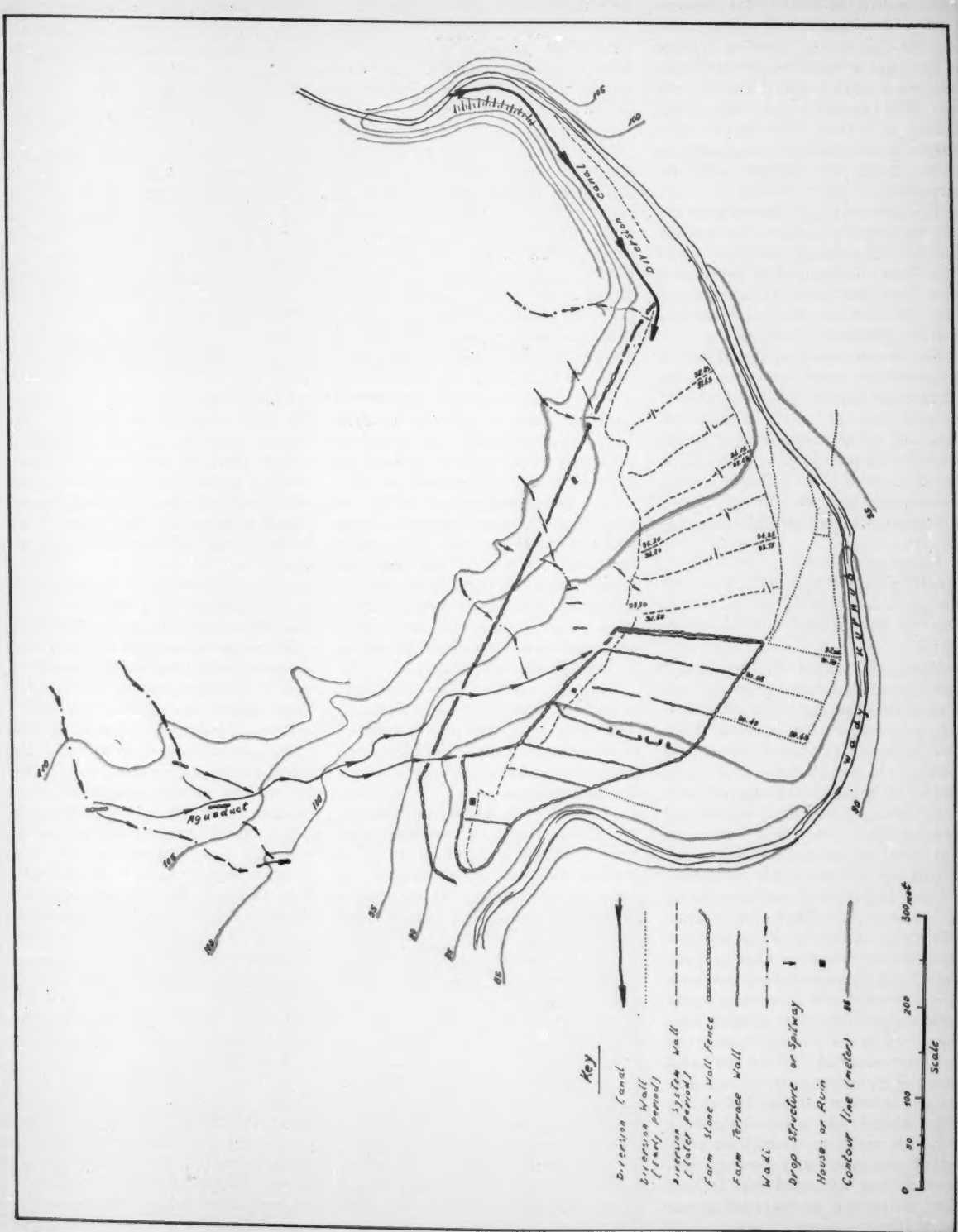


Fig. 7 (top). A map of the Mamshit system, which exploited runoff from a large watershed, showing the various periods of development. Fig. 8 (right). A vertical aerial photograph of the same system.

increases the runoff. Crust formation is prevented by the presence of a protective surface of gravel. Therefore, by clearing the slopes, the soil surface was exposed, crust formation was enhanced, and runoff was increased. This resulted in greater water yields from the slopes.

Thus, mounds were only a by-product of clearing the surface of stones. Strips sometimes fulfilled an additional function in channeling the water from the slopes to the fields. This is especially obvious in connection with the stone strips and conduits (see Fig. 2).

The fact that the mound and strip areas are always connected to the fields by channels (Fig. 2) is in conformity with this theory. Apparently this ingenious system was not restricted to the ancient desert agriculture of the Negev (*36*).

Exploitation of Runoff from Large Watersheds

For purposes of our work the term *large watersheds* is taken to mean watersheds greater than about 100 hectares in size. The hydrology of these large watersheds differs from that of small catchment areas. In the small catchment, runoff may begin after a small amount of rain (3 to 6 millimeters) has fallen, while on the other hand, a rainfall of at least 10 to 15 millimeters is required to cause a flow in the wadi of a large watershed (*37*, *38*). Furthermore, the percentage of runoff from a small catchment basin may be as high as 20 to 40 percent of the annual rainfall, but in the larger watershed it would not be greater than 3 to 6 percent. The small watersheds produce relatively small streams that can be handled easily by simple structures, whereas the flash-flood flows of the large wadis can destroy even the strongest of engineering structures. These factors led to the development of systems of water exploitation which differed both in form and extent from those described above for small watersheds. The Mamshit System is one of the best preserved. The ancient town of Mamshit is situated on a range of Turonian Cenomanian hills overlooking the Tureiba plain. Just south of the town, Wadi Kurnub cuts a narrow gorge through the Hatira anticline and enters the Tureiba plain. At the point where the gorge enters the Tureiba plain, the drainage basin has an area of about 27 square kilometers, and it was below this point that the flood waters from the large watershed were exploited.

Figure 7 is a map of this system and Fig. 8 is an aerial photograph of the area. A large diversion channel, about 400 meters in length, leads the diverted waters of Wadi Kurnub at a 2:1000 gradient to the flood plain. The original diversion dam has been completely destroyed but need only have been a simple rock structure to have raised the water level 30 to 50 centimeters in order to control the lower flood plain. This diversion channel leads the water to a series of broad terraces which are all in good condition. The terraces are more or less level in the transverse direction but have a slight gradient (2:1000 to 4:1000) in the direction of flow of the water. This arrangement made it possible to irrigate the area either in large basins or in small plots. The excess water from each terrace flowed to the next lower terrace through well-built drop structures.

The total area of the cultivated terraces is about 10 to 12 hectares. Agricultural experience has shown that about 3000 to 4000 cubic meters of water per hectare should be applied each year in order to insure an agricultural crop. This means that the watershed supplied about 40,000 to 50,000 cubic meters per year to the cultivated terraces. This represents less than 2 percent of the annual rainfall on the large watershed and could be expected every year as runoff. This quantity of water could have been carried by the diversion canal in 6 to 10 hours, according to the depth of flow (which probably did not exceed 40 to 60 centimeters).

A detailed examination of the area disclosed that the most ancient system was established when the wadi flowed in a shallow depression in the flood plain and before it had cut through the alluvial soils. The first walls were built primarily as stabilizing structures for the shallow depression, and only subsequently were they extended, in order to spread the water across the flood plain. Some of these walls can still be found on the opposite side of the wadi, showing that they predate the gulley stage of Wadi Kurnub. The most ancient potsherds found in the vicinity belong to the Middle Bronze and Iron ages, but there is still no certain evidence that this first system antedates the Nabataean period.

These stabilizing walls assisted in the deposition of alluvial silt in the terraces, and so their level was gradually raised. At some period, either through natural flood conditions or because the inhabitants abandoned the area for historical reasons, the wadi destroyed the stabilizing walls, and an ever-deepening gulley was cut through the system. The next users of the area were therefore faced with an entirely different problem: the runoff water no longer flowed in a shallow depression but concentrated in a wadi, one or two meters below the flood plain. They therefore had to base their system on a diversion structure which raised the water out of the wadi bottom and directed it to a diversion canal, which in turn led the water to the old terraces. The remains of this system stand out clearly on the aerial photographs and are the easiest to find in the field. Close inspection also revealed a number of diversions in the lower reaches of the wadi. These indicate that the elevations of the terraces were continually rising because of a silting process and that new diversion structures at higher elevations had to be built in order to control these new elevations.

Chronologically, the next system that is clearly discernible in the field seems to have been constructed when the diversion channel had become so silted that the whole system based on a diversion channel may have had to be abandoned. This system is based on a completely different principle. The main area with the diversion channel was not used, and only the lower terraces (about 3 to 4 hectares) were irrigated. This area was developed as a runoff farm and received its water from the relatively small watershed (3500 dunams) adjoining the area, not from Wadi Kurnub.

The system in Nahal Lavan (Wadi Abiad) (see Fig. 9) is much more complicated but nevertheless shows similar lines of development. Nahal Lavan is the largest wadi in the vicinity of the ancient town of Shivtah and drains from the high plateau of the Matrada through a large area of barren rocky Eocene hills. The torrential floods which have poured off these hillsides have cut a deep wadi through the alluvial plain. In the upper reaches, the plain is narrow (100 to 200 meters wide), but in the lower reaches the flood plain is more than a kilometer in width. Today the wadi is a gravel-bed watercourse typical of the area. All along these alluvial flood plains are

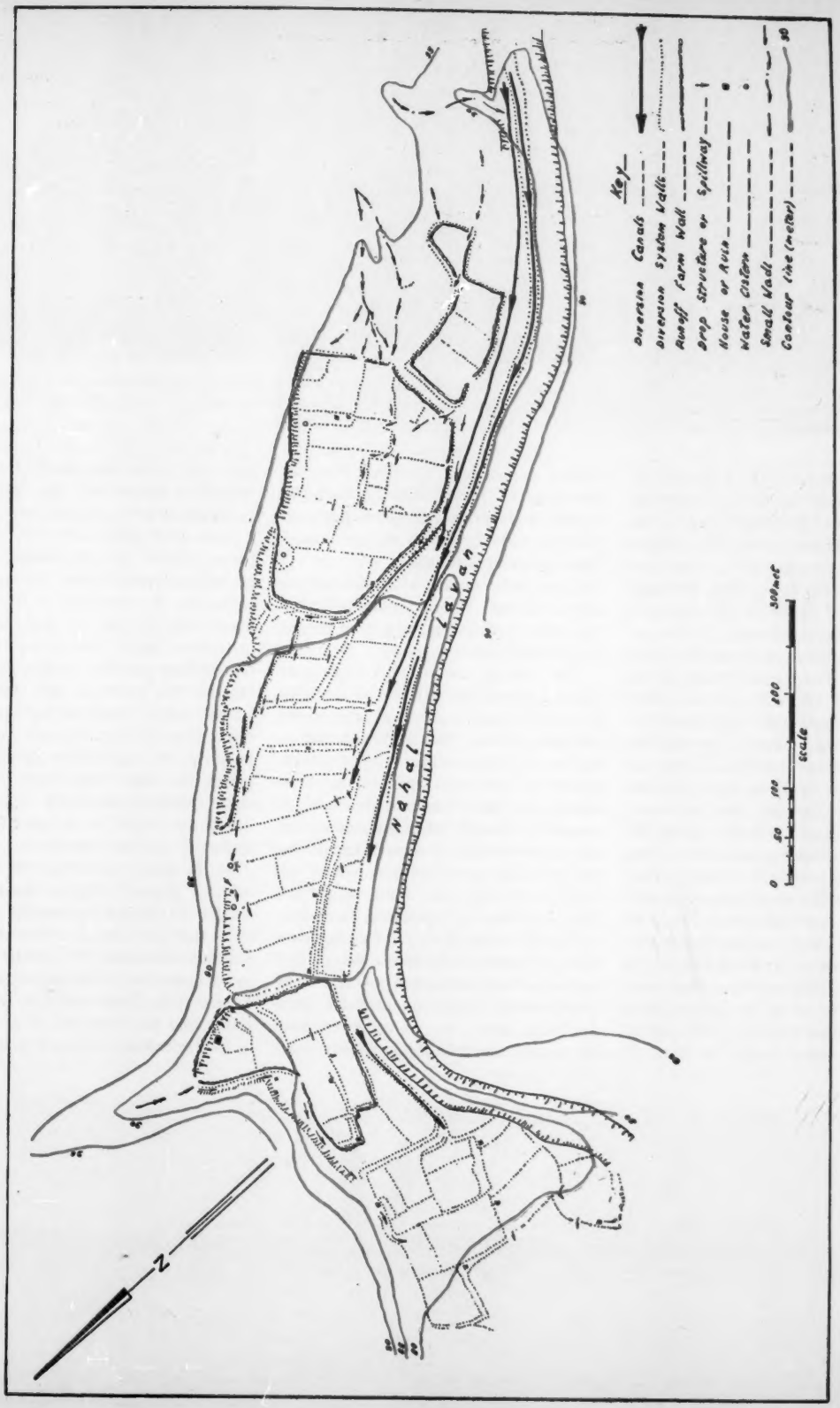


Fig. 9. Map of a section of the Nahal Lavan system.

Fig. 10 (above). A diversion canal wall of the Nahal Lavan system. Note the different stages of construction. The foundations are about 2 meters below the present soil surface. Fig. 11 (bottom of page). A large spillway with a crest length sufficient to allow passage of large floods.

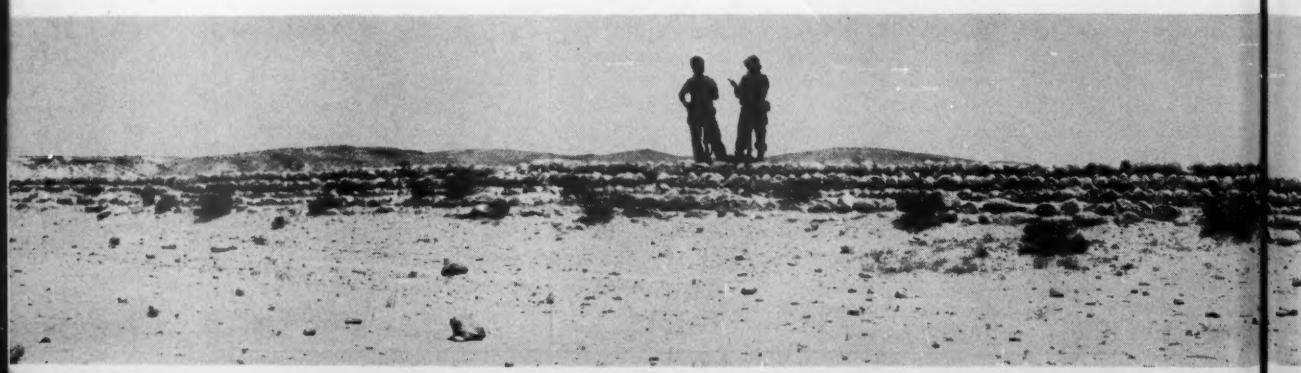
remnants of ancient walls and terraces, some of the walls reaching a height of 4 to 5 meters. These high walls (Fig. 10) attracted our attention, and a specific area covering 200 hectares was studied in detail (*39*). The drainage area of Nahal Lavan at this point is about 53 square kilometers.

A close examination of the area disclosed again the superimposition of many systems. For a long time it was difficult to unravel the intricacies of each period or even to differentiate between the systems. Only toward the end of the survey did we realize that the capacity and size of the spillways, canals, and drop structures give the key to understanding the area. The spillways, which served as drop structures to carry the water from one terrace to the next lower one, can be classified into three distinct categories: (i) spillways with crest lengths of 30 to 60 meters, capable of handling flows in the range of 10 to 30 cubic meters per second (see Fig. 11); (ii) spillways with a crest length of 3 to 8 meters, capable of handling flows in the range of 1 to 5 cubic meters per second; and (iii) small spillways up to 1 meter wide for flows of less than 1 cubic meter per second.

Using this criterion as a starting point, we were able to differentiate between three different types and stages of development.

The earliest use of the area was found in the lower reaches of the area surveyed, where well-constructed stone spillways with a 30- to 60-meter opening are the common form of structure. However, these spillways were not connected to any stone walls, and it seemed as though these structures were all that remained of some ancient system—that is, that the stone walls had been dismantled and only the structures had been left standing. However, a special helicopter reconnaissance flight revealed that these wide stone spillways were connected to faint lines in the fields. Inspection of these lines disclosed them to be the remains of earth embankments which had stretched across the flood plain. The complete extent of this flood-plain spreading system was not surveyed, but it was clear that it was in use long before Nahal Lavan became a deep gravel-bed watercourse. Some of the spillways are capable of handling a flood flow of up to 100,000 cubic meters an hour (see Fig. 11). The topographic situation of this system indicated that it was in use when Nahal Lavan was a shallow depression and that the earth embankments were built in order to spread the runoff waters across the wide flood plain. The wide stone spillways were used to control or direct the water as it passed from a higher to a lower elevation.

In the upper reaches of the surveyed area, a second system based on diversion canals and structures (capable of handling 1 to 5 cubic meters a second) was discovered. Some of these main diversion canals are more than a kilometer in length and 5 to 10 meters wide, and most possess a gradient of 4 to 5 percent. All lead to diversion



structures which served to divide the canal flow into as many as seven secondary canals leading to leveled terraces. Some of these terraces are in good condition, but most of them are badly eroded by gulleys which join Nahal Lavan 5 meters or more below the level of the terraced fields. Each diversion canal serves an area of about 2 to 4 hectares.

Detailed investigation of the walls of the diversion canals and the terraced walls associated with them showed that these systems were also built in stages. Figure 10 shows one of the diversion canal walls and the three distinct periods of construction. Excavation alongside the terraced walls showed similar periods of construction. These observations indicated that the diversion system silted up during its operation and that the settlers were continually faced with the problem of raising the elevations of the terraced walls as well as the diversion structures. Potsherds in the area dated from the Nabataean-early Roman period.

The next use of the area was again as runoff farms connected to adjoining small watersheds (Fig. 9). These farms adapted the existing structures and stone walls of the diversion systems to their needs and did not exploit the runoff from Nahal Lavan. Potsherds in the vicinity of these farm units generally dated to the Byzantine era.

We were originally under the impression that diversion systems of this type were widely used by the ancient civilizations. Although we have traveled widely in the area and have studied hundreds of aerial photographs, we have now come to the conclusion that this method was used only in very special restricted areas, and furthermore no diversion canal has been found that served more than 3 to 5 hectares.

All the systems studied showed a remarkable similarity in their development. This development is characterized by three stages each related to the erosion that was taking place in the flood plains and wadis associated with the large watersheds (*40*). This development can be divided into three stages, as follows:

Stage 1: Flood-plain development. The major wadis were originally wide shallow depressions meandering in alluvial plains. Cultivation of these depressions necessitated the construction of stone walls in order to stabilize the cultivated fields. These walls were subsequently extended so as to spread the water over larger sections of the flood plain (*41*).

The main spillways of this system were characterized by wide openings (30 to 60 meters) for handling the whole flood flowing in the depression. The embankments in some cases were built of earth.

This flood-plain development period dates back at least to the Nabataean period and may be earlier.

Stage 2: Diversion systems. At some stage, these flood-plain spreading systems were abandoned and the system deteriorated through lack of maintenance. During or subsequent to this abandonment, the wadi cut a deep gulley through the flood plain. The next settlers in the area utilized the technique of raising the water from the wadi with the aid of a diversion structure and leading the water by means of a channel to the flood plain. These diversion channels generally served small areas, and in most cases the new settlers utilized the remnants of the previous flood-plain development walls and structures. During this period the wadi continued to erode, and at the same time silt from the large watershed (or from the eroding banks of the wadi itself) was deposited in the terraced fields. This silt raised the level of the fields until a stage was reached

Fig. 12. An oblique aerial photograph of a chain-well system near Ein Ghadian.

that first necessitated raising the walls and later required the building of a new diversion structure higher up the wadi to raise the diversion canal.

The period of construction of these diversion systems must have been one in which the science of engineering was well developed, since all the structures required sound knowledge of hydrology and hydraulics. Furthermore, this period must have been one in which a central authority controlled the whole system and had the legal authority to distribute the flows during the short flood period that occurred in the ephemeral wadis. In both the Roman and Byzantine periods these conditions existed, and the Roman and Byzantine potsherds found in the area probably relate to this diversion-system period.

Stage 3: Runoff farms. The diversion system may have become unmanageable because of the silting problem, or serious flood conditions may have de-

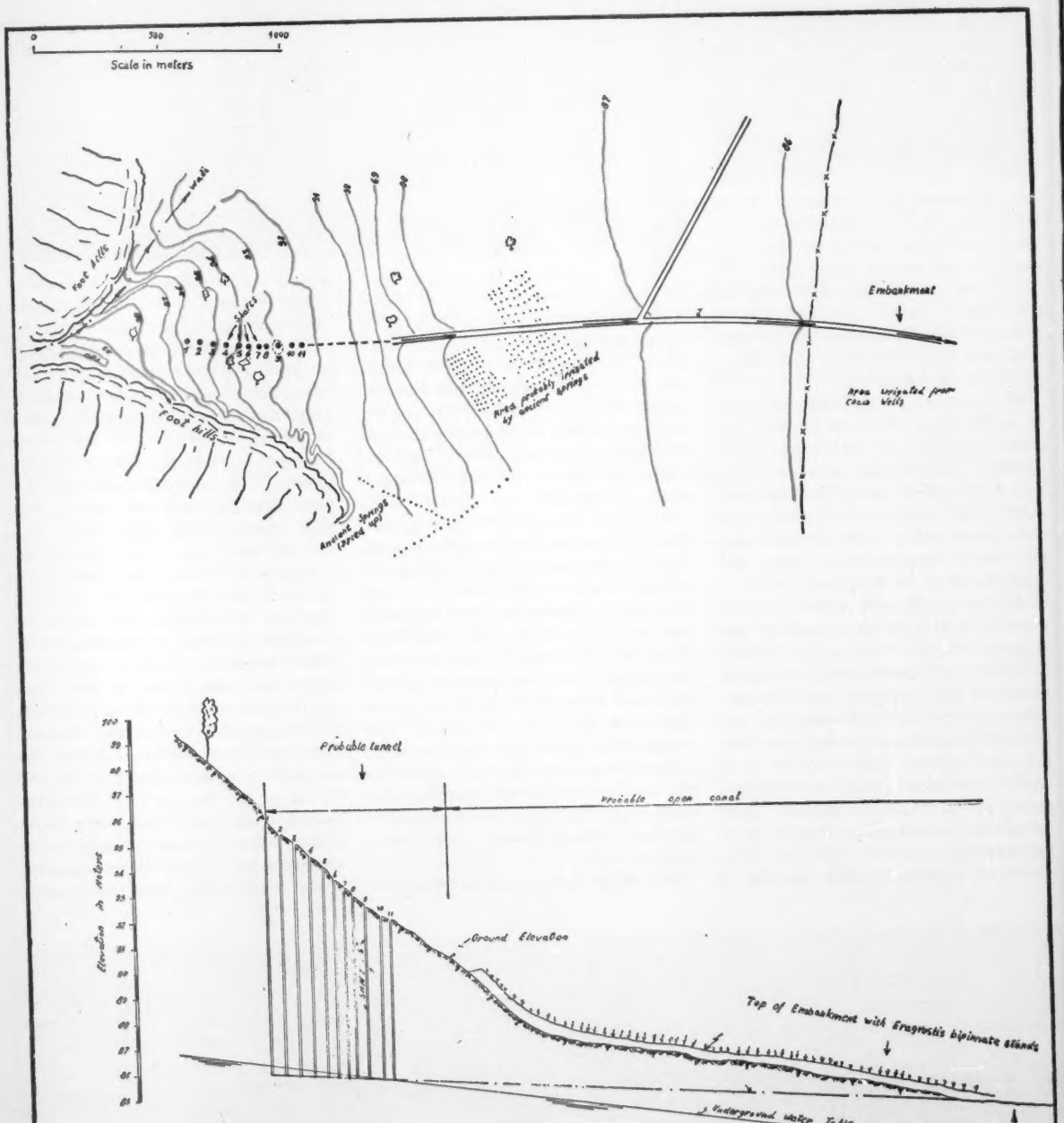


Fig. 13. Details of a chain-well system near Ein Ghadian.

stroyed the main diversion features, and the system was abandoned. The next system no longer relied on the main wadis but utilized the small watersheds adjoining the area in order to obtain the required runoff water. These runoff farms adapted existing walls and structures to their new requirements and generally utilized only part of the original diversion-system area (*42*).

Chain-Well Systems

In the Middle East and Central Asia, chain-well systems ("artificial springs") have been used since ancient Persian times and are still widely used today. Their construction and operation have been fully described in the literature (*43*).

While well digging was a common method of exploiting shallow groundwater resources in the ancient civilizations in Palestine, the more intricate chain-well systems have only been found in Jordan and the Arava Rift Valley (*37*, *44*). As the mean annual rainfall in the valley is only about 40 millimeters and this amount of rainfall is without agricultural value, the chain-well systems must have been the main source of irrigation water.

Chain-well systems have been located at three oases in the Wadi Arava Rift Valley. The largest and most intricate is near the Ein Ghadian (Yotvata) oasis. Other systems were discovered near Ein Zureib and near Ein Dafieh (Ein Evrona) (*45*). Since these systems are hardly discernible on aerial photographs and are difficult to discover from the air or even in the field, it is likely that a thorough investigation of the Wadi Arava would disclose many other systems.

A chain-well system is composed of three essential parts: (i) one or more wells (sometimes called "mother-wells") dug down to the water table; (ii) an almost horizontal underground tunnel leading the water, at small gradient, to the soil surface and ending in an open ditch; and (iii) vertical shafts connecting the tunnel to the ground surface. These shafts facilitate the construction of the tunnel and the disposal of excavated material in a molelike fashion and also provide access and ventilation to the tunnel for maintenance purposes. The surplus excavated material is deposited near the shafts, forming a circular mound around the shaft opening.

The oasis of Ein Ghadian, which was examined in detail, is presented as a typical example of a chain-well system of the Arava Valley. The oasis itself is of the playa type, and the central part, where the water table is 1 to 1.5 meters deep, is saline and sterile. It was natural that this oasis, the largest on the western side of the Arava valley floor, was constantly settled. There are several remnants of ancient settlements extending from Middle Bronze to Roman-Byzantine times. Ein Ghadian was also the first station on the Roman road from Eilath to the north of Palestine (*46*).

Figure 12 shows a part of one chain-well system at Ein Ghadian as seen from the air; Fig. 13 shows details of one of the systems.

The chain-well systems vary in length; some are 3 to 4 kilometers long, others seem to be only a few hundred meters long. The vertical shafts are spaced at distances of about 15 to 25 meters, center to center. In most systems, only relatively few of the original circular mounds and shafts are still intact, owing to the obliterating action of winter flash floods. In those sections where the danger of destruction by floods was greatest, remnants of stone protection walls are found on the upstream side of the line of shafts.

All systems apparently begin in the gravelly wadi-fans on the western edge of the Arava depression and may possibly be connected to a definite fault line. The tunnel part of the system always seems to terminate in an elevated earth ridge on which there is a thick growth of *Eragrostis bipinnata* ("love grass"). These ridges are probably the old irrigation channels.

The systems and their channels lead to the northwestern edge of the Ein Ghadian playa, which is covered by stands of *Eragrostis bipinnata* rooted in the water table. Closer inspection reveals that the individual tussocks of *Eragrostis bipinnata* form regular checkerboard patterns. It is possible that these stands indicate the area of ancient irrigation. Each tussock would then represent an irrigated basin, or possibly the point where a palm tree was rooted. However, if the water level in ancient times was different, the irrigable area would, of course, have changed correspondingly.

Practical application. Many authors (*47*), investigating the area, have suggested that the ancient and forgotten civilizations of the Negev could teach a practical lesson for the future. We, too, felt that some of the principles

Fig. 14. An aerial photograph of the reconstructed Shivtah farm. Note one branch of one runoff conduit entering the farmhouse, bringing water to an underground cistern.

on which the ancient civilizations developed their desert agriculture could be applied today. The written records of ancient agriculture in the desert are limited principally to the Nessanah documents (*48*). But even the little information given in these publications encouraged us in this line of thinking.

However, the first question that we had to decide was whether there had been any climatic changes during this period of time. We are of the opinion that there has been no major climatic change in the area—that is, that the Negev has always been a desert with an average annual rainfall of about 100 millimeters. If there had been a more humid climate in ancient times, there would have been no need to develop this ingenious desert agriculture based on maximum water conservation; necessity was the mother of invention. However, we are also of the opinion that there were definite variations in the average annual rainfall. The 20-year moving average may have fluctuated between 70 and 150 millimeters, but these differences would probably have evened out on a 100- to 200-year moving average.

Fig. 15. The reconstructed ancient farm near Avdat. Note the farmhouse on the hill. The reconstructed conduits leading runoff from the small watersheds may be seen in the background.

We then decided to reconstruct two ancient runoff farms, one near Shivtah and one near Avdat. In doing so, our aims were (i) to collect exact data about rainfall and runoff and, if possible, develop an analytical relationship between them, and (ii) to find out what, if any, agricultural crops and fruit trees could be grown by utilizing *only* the runoff from small watersheds.

After a careful survey, both farms were reconstructed with all their terraces, walls, and channels.

The Shivtah farm. The runoff farm shown in Fig. 14 was chosen for reconstruction (*49*). The reconstruction was started in the summer of 1958. Where a channel of the wadi led water into the farm, a weir and an automatic flood-recording gauge were built. A meteorological station was erected near the farm, and nine automatic and simple rain gauges were distributed over the whole catchment area. In February 1959, after the first flood, 250 fruit trees and vines were planted (grape, almond, apricot, peach, plum, carob, olive, pomegranate, and fig). During the summer of 1959 the young trees received small amounts of additional irrigation in order to insure their establishment. From then on, they received only runoff water from the small watersheds. The results by August 1960 were very encouraging, since during this short period the young saplings grew from a height of 40 to 50 centimeters into trees 2 to 2.50 meters high, despite the fact that both years were severe drought years, the season 1959–60 being the driest one since meteorological measurements were established in Palestine-Israel. During the coming rainy season (1960–61) we will plant another 50 fruit trees.

The Avdat farm. This reconstructed farm lies at the foot of the hill on which the ancient city of Avdat is situated. Its reconstruction was started in July 1959 after a careful topographic and soil survey.

The soil (as in the case of the Shivtah farm) is the typical aeolian-fluviatile loess of the Negev. It is uniform over the whole farm area with the exception of small strips in the upper part and along the sides of the farm. These parts will not be used for

Fig. 16. Harvesting barley on the Avdat farm in May 1960.

our agricultural experiments. The loess is uniformly 1.50 to 2.50 meters deep. A farmhouse (see Fig. 15) containing a laboratory, a kitchen, two sleeping rooms for the staff, and one sleeping room for visiting scientists was built on the hill overlooking the farm (*50*). Near the house there is a meteorological station more complete than that at the Shivtah farm. Two automatic and 17 simple rain gauges were distributed over the whole area. Eight weirs and automatic runoff recording gauges were set up as described for the Shivtah farm.

After the first rain of 16 to 22 millimeters, in November 1959, a heavy flood wetted the whole farm area down to a depth of 1 to 2.5 meters. Barley of the Beacher variety was sown. It sprouted quickly and was harvested in May 1960. On selected parts of the area, the yield was 125 kilograms per dunam (or 500 kilograms per acre) (Fig. 16). This is a quite astonishing yield for this most severe drought year, with only 40 millimeters of rain, when thousands of dunams of barley in the more northern area of Israel, with 80 millimeters and more of rain (but without additional runoff), failed utterly.

On the basis of the encouraging results of the first year, our agricultural committee has drawn up the following plan, which is now being carried out (*51*) for the coming rainy season.

1) Field crops: 80 plots (3 by 25 meters) will be established. The water-distribution system to these plots is so arranged that the plots will get equal, known quantities of runoff water and there will be full control of this distribution of the flood runoff. The plan provides for different field crops to be sown according to the time of year when the first flood occurs and according to the depth of penetration.

2) Pastures: 10 plots will be established as nursery areas. An additional 5 to 7 dunams will be used as observation areas which will receive only partially controlled quantities of runoff water.

3) Orchards: On 10 to 12 dunams, 200 fruit trees and vines will be planted (pistachio, cherry, peach, apricot, and grape).

References and Notes

1. E. H. Palmer, *The Desert of Exodus* (Cambridge, England, 1871).
2. For phytogeographical, phytosociological, and ecological data about the Negev, see H. Boyko, *Palestine J. Botany Rehovot Ser.* **7**, 17 (1949); D. Zohary, *Palestine J. Botany, Jerusalem Ser.*, **6**, 27 (1953); M. Zohary, *ibid.* **4**, 24 (1947); ——— and G. Orshan, *Végetatio* **5–6**, 341 (1954); M. Zohary. *Geobotany* (Sifriath Hapoalim, 1955) (in Hebrew).
3. The question of the minimum "effective" rainfall is a most important one for all desert areas. N. H. Tadmor and D. Hillel [Israel Agr. Research Sta. Rehovot, paper No. 38 (1957)] suggest that rainfall in amounts of less than 10 to 15 mm is "ineffective"—that is, has no or little effect on vegetation and runoff. Y. Kedar [*Econ. Quart.* **5**, 444 (1958) (in Hebrew)] estimates that 50 percent of the average yearly rainfall in the Negev is effective. However, our own first measurements showed that rainfalls much smaller than 10 to 15 mm are effective and start runoff.
4. For the history of the Negev, see the many publications of N. Glueck and especially his book *Rivers in the Desert* (Farrar, Straus, and Cudahy, New York, 1959). As for prehistoric times, there is much evidence of prehistoric settlement in the Negev, perhaps even reaching back to the Palaeolithicum [see N. Glueck, *Bull. Am. Schools Oriental Research* **142**, 17 (1956)]. Concerning the Chalcolithicum, we may have to change our opinion, as N. Glueck [*Biblical Archaeologist* **22**, 82 (1959)] reports that he found chalcolithic sites in the Central Negev.
5. An excellent historical sketch on the Nabataeans has lately been written by J. Starcky [*Biblical Archaeologist* **18**, 84 (1955)]; see also M. Evenari and D. Koller, *Sci. Am.* **194**, 39 (1956).
6. N. Glueck [*Biblical Archaeologist* **22**, 82 (1959)] writes of this period: "The Byzantine period in the Negev came to an end . . . as a result of the Mohammedan conquest. Darkness and disintegration and reversion to desert have characterized its history since then."
7. M. Evenari, Y. Aharoni, L. Shanan, N. H. Tadmor, *Israel Exploration J.* **8**, 231 (1959); Y. Aharoni, M. Evenari, L. Shanan, N. H. Tadmor, *ibid.* **10**, 23, 97 (1960).
8. N. Glueck has stressed this point in his surveys of the Negev published in many issues of the *Bulletin of the American Schools of Oriental Research*; see also N. Glueck, *Rivers in the Desert*. See also F. M. Cross and J. T. Milik [*Bull. Am. Schools Oriental Research* **142**, 5 (1956)], who reported Iron Age II sites and desert agriculture from the wilderness of Judaea (Wadi Buqeah, near Qumran). According to their description, they found what we call "runoff farms."
9. The Middle Bronze I period presents two main problems. To what ethnic group did the people of this period belong? N. Glueck [*Bibica! Archaeologist* **18**, 2 (1955); *Bull. Am. Schools Oriental Research* **149**, 8 (1958)] calls this period in the Negev the "Abrahamitic age." But the scholars are not yet agreed on the date of Abraham's wandering through the Negev. Even if Glueck's date is right, the people of this period cannot be identified with Abraham's people. The second question arises in connection with the occupation of the people in the Middle Bronze I period. Were they cattlemen or agriculturists or both? Glueck [*Bull. Am. Schools Oriental Research* **138**, 7 (1955)] calls them "Tillers of the soil" and states in many of his publications that they practiced agriculture. However, no investigator has yet related ancient fields to any of these settlements.
10. R. Calder, *Man Against the Desert* (Allen and Unwin, London, 1951).
11. J. Baradez, *Fossatum Africae* (Arts et Métiers Graphiques, Paris, 1949).
12. Carton, *Rec. notes et mém. soc. archeol. Constantine* **43**, 193 (1909).
13. O. Brogan, *Illustrated London News* (22 Jan. 1955); M. Renaud, *Rev. agr. Afrique du Nord* **56**, 689 (1958).
14. Carton, in his excellent paper, was perhaps the first to recognize clearly the main principles of ancient desert agriculture—that is, the use of runoff from sterile hills and the storing of the runoff water in the soil. He writes: "Il s'agit ici d'ouvrages ayant pour but *non pas l'irrigation proprement dite, mais l'inondation ou la submersion*" (italics ours). The main aim of the system was "de faire pénétrer lentement et profondément l'eau dans le sol." He was the first, too, to point out "l'ingénuité et la prévoyance des Anciens qui, au lieu d'énormes barrages-réservoirs, coûteux et dangereux, destinés à l'irrigation, avaient préféré réserver l'eau dans ces immenses réservoirs-souterrains . . . ." We cite him verbatim because his paper is not easily available. Though this desert agriculture flourished most in Roman times, Carton is of the opinion that it may be older than the times of Carthage and Rome and dates perhaps back to the old Berber population.
15. A. de Poidebard, "La trace de Rome dans le désert de Syrie," (Librairie orientale P. Geuthner, Paris, 1934); S. Mazloum in R. Mouterde and A. de Poidebard, *Le limes de Chalcis* (Librairie orientale P. Geuthner, Paris, 1945).
16. N. Glueck, *Ann. Am. Schools Oriental Research* **14** (1934); **17-19** (1939); **25-28** (1951).
17. F. Stark, *Geograph. J.* **93**, 1 (1939); H. St. J. B. Philby, *Sheba's Daughters* (Methuen. London, 1939); W. Phillips, *Quataban and Sheba* (Harcourt, Brace, New York, (1955); R. L. Bowen, Jr., in *Archaeological Discoveries in South Arabia* (Johns Hopkins Press, Baltimore, 1958). Special mention must be made of the enormous ancient irrigation dam of Marib—possibly the biggest ever built in ancient times—constructed in the 8th century B.C., which broke down in the 6th century A.D. [E. Glaser, *Reise nach Marib* (Hölder, Vienna, 1913); A. Grohmann in *Encyclopedia of Islam* (Brill, Leiden, 1913)]. The oldest irrigation dam, which apparently broke immedately after it was finished, was found in Egypt, dating back to the IIIrd or IVth dynasty (about 3000 B.C.) [see B. Hellström, *Houille blanche* **1952**, No. 3, 424 (1952)].
18. E. F. Castetter and W. H. Bell, *Pima and Papago Agriculture* (Univ. of New Mexico Press, Albuquerque, 1942); *Yuman Indian Agriculture* (Univ. of New Mexico Press, Albuquerque, 1951).
19. G. de Reparaz, *El programa de estudios de la zona arida Peruana* (UNESCO, 1958).
20. See L. Shanan, N. Tadmore, M. Evenari, *Ktavim* **9**, 107 (1958); **10**, 23 (1960).
21. D. Hillel, *Bull. Israel Agr. Research Sta. Rehovot* **63**, 1 (1959) in Hebrew with English summary).
22. These farm fences apparently served two purposes. They are a symbol of property [Y. Kedar, *Israel Exploration J.* **7**, 178 (1957)] and, at the same time, a control structure. Most of them run around the farm at the base of the slopes preventing undesired material from the slopes from being carried into the fields and permitting the runoff water to enter the fields only at the places desired [see also N. Glueck, *Bull. Am. Schools Oriental Research* **149**, 8 (1958); **155**, 2 (1959).
23. In an earlier paper [M. Evenari and G. Orshansky, *Lloydia* **11**, 1 (1948)], hammadas were described as follows: "Hammadas are slightly rolling gravelly desert plains whose surfaces are strewn with vari-sized stone fragments and pebbles. Such fragments are brown or black, encased in the so called 'Schutzrinde' of the German authors, regardless of whether the core itself is composed of chalk, granite, flint, or schist. The brown and black surface of the pebbles shines brightly as it is covered by the 'desert lacquer' . . . . This black lacquer gave rise to the Arab legend that these stones were scorched by heavenly fires."
24. Y. Kedar, *Bull. Israel Exploration Soc.* **20**, 31 (1956) (in Hebrew with English summary).
25. Kedar was the first to point out the difference between stone and gravel mounds, according to the lithological material available.
26. A. Musil, *Arabia Petraea* (Hölder, Vienna, 1907); T. Wiegand, *Sinai* (Gruyter, Berlin and Leipzig, 1920); C. A. Woolley and T. E. Lawrence, "The wilderness of Zim," *Palestine Exploration Fund Annual* (1914–15).
27. P. Mayerson, *Bull. Am. Schools Oriental Research* **153**, 19 (1959).
28. Most of the arguments against this theory are discussed in N. H. Tadmor, M. Evenari, L. Shanan, D. Hillel, *Ktavim* **8**, 127 (1957). N. Glueck [*Bull. Am. Schools Oriental Research* **149**, 8 (1958); **155**, 2 (1959)] and Y. Kedar [*Bull. Israel Exploration Soc.* **20**, 31 (1956); *Geograph. Rev.* **123**, 179 (1957)] also refute Palmer's (and Mayerson's) theory. There are only two points of Mayerson's which merit attention additional to that given by Glueck (1959). First, Mayerson presents a photograph of some stone heaps which were not on a slope but in a wadi bottom and uses this single observation as an argument against Kedar, Glueck, and ourselves. He fell victim to an error, as the rubble piles depicted in his photograph from Wadi Isderiyeh are the leftovers of a relatively recent excavation made by the Mandatory Government of

Palestine for a telephone cable which was laid along Wadi Isderiyeh. Second, Mayerson agrees that the vineyards planted on the slopes could not have existed on the available rainwater, but he believes that they were hand-irrigated from water stored in cisterns. A very simple calculation, already partly made by Kedar, shows that this is an impossibility. Kedar calculates that there are about 80 mounds per hectare (this is an underestimate; Mayerson talks about 600 per hectare) and that about 2300 hectares are covered by these mounds in the vicinity of Avdat. We estimate that each vine planted on or near a mound would require at least 0.5 cubic meter of additional water per year. The ancient farmers would, therefore, have had to supply 92,000 cubic meters as additional irrigation. Kedar has calculated that all the cisterns in the vicinity do not contain more than 4000 cubic meters altogether. The discrepancy between the figures is even more enormous if we assume that the people used some of the water from the cisterns for domestic purposes, and for cattle, as the Bedouins do today.

29. H. Boyko, *Proc. UNESCO Symposium on Plant Ecol.* (1955), pp. 1–8.
30. A. Reifenberg, *The Struggle between the Desert and the Sown* (Mossad Bialik, Jerusalem, 1955).
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35. N. Glueck [*Bull. Am. Schools Oriental Research* **149**, 8 (1958)] came to the same conclusions.
36. G. Caton Thompson and E. W. Gardner [*Geograph. J.* **93**, 32 (1939)] report "evenly spaced stone-rubble heaps" tied up with ancient fields from Hadhramaut, and W. J. H. King [*ibid.* **39**, 133 (1912)] reports similar findings from Lybia. Photographs in the book of Baradez (*11*) seem to show areas of mounds and strips on the slopes near ancient fields in Algeria. A most interesting observation was made by B. Hellström [*Roy. Inst. Technol. Stockholm, Inst. Hydraulics, Bull. No. 46* (1955)]. In the desert between Cairo and Alexandria he found numerous sand walls called today *kurum* (compare our *rujum el kurum*), dating from Roman times. His explanation is as follows: "When it was raining, the water ran quickly downwards along the sides of the walls . . . . The walls were constructed for the sole purpose of irrigating surrounding cultivated areas by means of the discharging water . . . . The areas along the walls were used for vineyards."
37. M. G. Jonides, "Report on the water resources of Transjordan and their development," *Publ. Govt. Transjordan* (London, 1939).
38. A. Schorl and D. Krimgold, *Internal Rept. Dept. Agr. Israel* (1959) (in Hebrew).
39. Kedar [*Israel Exploration J.* **7**, 178 (1957)] studied part of this area. However, he did not differentiate between the various periods of development in the area, and hence he shows the system as having been built and operated all at one time.
40. Kedar (*24*, *32*) indicates a different erosion cycle. We feel that he did not notice the superimposition of earlier structures on later ones.
41. Examples of this flood-plain development were mentioned in our work on the Matrada plain and Sahel-El Hawa (*7*) and are common in all those flood plains where the main wadi has not yet eroded down below the flood plain. In these areas the process of active head gulley growth can be seen even today. A deep gulley (2 to 4 m deep) is cutting into the flood plain, progressing at a rate of tens of meters per year and so changing the base level of the area.
42. The cultivation of shallow depressions (stage 1) probably also occurred in the small watersheds, and the simple terraces and cultivation of wadis found in these areas may relate to this stage. But we have not yet studied in detail either the hydrology or the historic development of this type of desert agriculture. Moreover, we have only begun an investigation of the role the numerous water cisterns played in collecting runoff from small watersheds for domestic purposes. It should also be pointed out that, although the final use of the diversion areas was as runoff farms, the runoff farms occur mainly in areas which were never related to diversion projects.
43. See, for example, M. Cressey [*Geograph. Rev.* **48**, 27 (1958)], A. Smith [*Blind White Fish in Persia* (Allen and Unwin, London, 1953)], and A. Reifenberg (*30*).
44. B. Aisenstein, *J. Assoc. Engrs. and Architects in Palestine* **8**, 5 (1947).
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46. Y. Aharoni, *Eretz-Israel* (1953), vol. 2, p. 112 (in Hebrew); F. Franck, *Z. deut. Pal. Ver.* **57**, 191 (1934).
47. N. Glueck, in many of his papers cited in these notes; Y. Kedar, *Econ. Quart.* **5**, 444 (1958) (in Hebrew); Carton (see *12*), who writes: "Il peut être . . . intéressant de montrer que les études archéologiques méritent d'être favorisées *en raison des enseignements utiles* qu'elles peuvent donner" (italics ours); Woolley and Lawrence [*Palestine Exploration Fund Annual* (1914–15)], who write: "We believe that today . . . the Negev could be made as fertile as it ever was in Byzantine times."
48. C. J. Kraemer, Jr., *Excavations at Nessanah* (Princeton Univ. Press, Princeton, N.J., 1958), vol. 3.
49. Jossi Feldmann, then a member of *kibbutz* Revivim, carried out the reconstruction work at the Shivtah farm. The agricultural planning for both farms is done by an agricultural committee headed by Dr. J. Carmon. Its members are Dr. Samish (fruit trees) and Dr. R. Fraenkel (field crops), both from the National and University Institute of Agriculture; M. Hilb, Government Minister of Agriculture; J. Dekel, Jewish Agency; and M. Eshel, Government Department of Soil Conservation. Joel de Angeles, from Revivim, is responsible for carrying out the agricultural planning.
50. The farmhouse is called "The Lauterman Negev House" and is a gift of Rose Annie Lauterman, Montreal, Canada. We hope that scientists interested in animal or plant ecology of deserts will use this opportunity to study desert fauna and flora *in situ*. We ourselves, in addition to pursuing the hydrological and agricultural aims of the project, are carrying out an ecological-physiological investigation of the main desert plants, based on fixed observation plots around the two farms.
51. This investigation was supported by the Ford Foundation, the Rockefeller Foundation, and the Irsaeli Government. Our studies of ancient agriculture were supported by a grant from the Ford Foundation; the reconstruction and agricultural work was and is being financed by the Rockefeller Foundation and the office of the Israeli prime minister. Our thanks are due to the Israeli Air Force for the aerial photographs and to Mrs. L. Evenari for the ground photographs.

The College-Student Image of the Scientist

Scientists are seen as intelligent and hard-working but also as uncultured and not interested in people.

David C. Beardslee and Donald D. O'Dowd

The image of the scientist among high school students has been studied in detail in recent years. Remmers and Radler (*1*) have reported on some beliefs of teen-agers about scientists, and Mead and Metraux (*2*) have summarized the image of the scientist revealed in essays produced by a large sample of high school students.

The beliefs of college students about the scientist are also of interest. Many students entering college seriously consider careers in science, and college students will eventually constitute an influential segment of the citizens whose views make up the public response to science.

Exploration of the college-student image of the scientist was initiated in a series of unstructured interviews with college undergraduates at Wesleyan University (*3*). In these interviews, students described the scientist as being dedicated to his work and carrying it out with heroic devotion at the expense of concern with public affairs and even family responsibilities. The scientist was described as unsociable, introverted, and possessing few, if any, friends. Some students referred spontaneously to his high intelligence; others were more impressed by the precision of his thinking and the objectivity (that is, lack of emotional involvement) with which he handles most personal and professional problems. Two telling comments represent the common response of undergraduate men to the scientist. One student volunteered, "I wouldn't care to double-date with a scientist," and another student commented, "maybe it's not a good idea for him [the scientist] to be married." A number of students were impressed by the scientist's apparent need to proceed in his work regardless of other demands on his time. In general, the college students revealed in these interviews beliefs similar to those found among high school students. The scientist, to use the student phrase, "is not well rounded."

In order to pursue further the subject of the student image of the scientist, a series of three successive questionnaires was designed and used in testing. A fourth version of the questionnaire was selected as the main instrument for an empirical study. It contained materials derived from the interviews and from standard questionnaires and scales developed in the earlier versions. In the questionnaire students were asked to indicate the appropriateness of a series of terms to each of 15 occupations, including that of scientist (*4*). The terms were arranged in two-ended, seven-point rating scales of the following form (*5*):

1. wealthy —:—:—:—:—:—:— not well-to-do
2. optimistic —:—:—:—:—:—:— pessimistic
3. excitable —:—:—:—:—:—:— calm

This design makes it possible not only to determine absolute values for characteristics attributed to the scientist but also to obtain an estimate of the standing of the scientist relative to individuals in other occupations.

The questionnaire was given to undergraduate men and women in four colleges in the northeastern United States: Wesleyan University, a second small and highly selective men's liberal arts college, a highly selective private women's college, and the college of arts and sciences of a state university (*6*). At each college, probability samples of freshmen and seniors were chosen. Over 90 percent of the students selected at three of the four colleges returned completed questionnaires. At the second men's liberal arts college, all of the freshmen but only two-thirds of the seniors completed the questionnaire. Data from these seniors were not used in many of the following analyses. In all, about 1200 students were included in this phase of the study (*7*).

Image of the Scientist

It is possible to present a composite picture of the scientist from the responses obtained. Students from all of the colleges, both men and women, freshmen and seniors, were in sufficient agreement to justify a summary of the characteristics attributed to the scientist by all groups. There is clearly a well-defined stereotype of the scientist among college students as well as among high school students. In the following summary, the rating of the scientist relative to individuals in other occupations is considered.

The scientist, according to college students, is outstanding in several respects. Students see him most prominently as a highly intelligent person with a strong tendency to be both individualistic and radical in personal and social outlook. At the same time, the scientist is seen as socially withdrawn; he is indifferent to people, retiring, and somewhat depressed, and he rates low in social popularity. In overall sociability the scientist rates lowest among individuals in the 15 high-level occupations. It is therefore not surprising that he is believed to have a relatively unhappy home life and a wife who is not pretty. There is an air of strangeness about him; he is hard to like and comprehend. He is respected for his great contribution to society, but he is not the kind of person one can easily get to know.

The scientist is believed to be highly intelligent but not interested in art. He is both self-sufficient and persevering. He focuses his powers in a rational and sensitive pursuit of answers to nature's mysteries. He is rated as reasonably successful and as having ample opportunity to advance in his field. At the

The authors are associate professors of psychology, Michigan State University Oakland, at Rochester, Mich.

same time he is seen as having only modest wealth. It appears that the scientist could exploit his situation to secure wealth and status, but he is so devoted to his work that he is satisfied with a modest income.

The scientist is moderately confident, optimistic, and realistic in his approach to life. He has power in public affairs yet is given only a moderately high score on responsibility. When combined with his radicalism, this finding suggests that there are grounds for an anxious public to become suspicious of his loyalty. After all, he has few friends, great determination, and an unusual set of values.

Rather surprisingly, the scientist is scored relatively low on stability, caution, and calmness. It appears that he has difficulty controlling his impulses. This is consistent with the picture of his radicalism. He is coldly intellectual in some spheres of his life—mainly in his work—and he is emotional in his response to social and political appeals.

The complexity of the scientist's nature must account for his being considered mildly interesting and colorful. He is thought to be very valuable to society and to derive very great personal satisfaction from his work. If one were to study his recreational habits one would find him most frequently at chess, rarely playing bridge, and never playing poker.

In summary, there emerges a picture of the scientist as a highly intelligent individual devoted to his studies and research at the expense of interest in art, friends, and even family. The scientist derives great personal satisfaction, a sense of success, reasonably high status in the community, and a modest income from his work. He serves mankind in a selfless way, almost unaware that he is doing so; he serves others by serving himself.

In public matters the scientist is influential, but he may be somewhat naive. He is extreme in his views on social matters, and he tends to become emotionally involved with issues outside his realm of professional competence. The scientist is coldly intellectual in his professional area but excitable in the public political sphere. He is clearly an intellectual, but unlike "eggheads" in the humanities, he is characterized by a vigorous and directed use of his intelligence. The image conveys a sense of strength of personality, but it is a little extreme, a little strange, somewhat contradictory, and, therefore, hard to comprehend.

Comparison with Images of the Nonscientist

An estimate of the similarity of the scientist image with the images of individuals in 14 other occupations was obtained by correlating the mean scores obtained on 48 scales for the scientist and for people in these other occupations. The data from a subsample of the students tested were used to obtain the correlations presented in Table 1.

These data reveal that the scientist is believed to have much in common with the college professor. The similarity of ratings for the scientist and engineer was predictable, but the correlation with ratings for artist and school teacher had not been clearly foreseen. This correlation stems primarily from the students' grouping of all these roles as intellectual roles. It is clear that the students believe that scientists do not share many attributes with individuals in any of the business and industrial occupations.

Comparison of the image of the scientist with that of the college professor reveals some interesting differences between these roles that are often filled by the same person. Both occupations are entered by men of high intelligence with personality characteristics represented by high scores on *self-sufficient* and *persevering*, middle values on *strong, active, confident*, and *self-assertive*, and low scores on *stable* and *adaptable in habits*. Both professions are believed to attract men who are, to a high degree, radical and individualistic. Members of the two professions differ in that the scientist is thought to lack the artistic interest, good taste, and sensitivity of the college professor. The scientist is not a cultured intellectual, while the college professor attains the highest score in this dimension. Moreover, the scientist is, to a striking degree, less interested in people and less sociable and popular than the college professor. The professor is interested in people and quite successful with them. The scientist is neither drawn to people nor socially attractive. Finally, the scientist is less interesting and colorful than the college professor. The scientist is scored above the college professor on two components of what might be called "material opportunity"—that is, wealth and the opportunity for advancement. The scientist has a more markedly active, persevering, and rational approach to life and work than the professor. In summary, the scientist has greater wealth and opportunity than the professor and a more forceful approach to intellectual problems. However, in the very important areas of social sophistication and esthetic interests the college professor leads the scientist by a wide margin.

Table 1. Correlation of the profile of the scientist with profiles of individuals in other occupations.

Occupation	Correlation
College professor	+ .77
Engineer	+ .53
Artist	+ .51
School teacher	+ .49
Doctor	+ .44
Lawyer	+ .41
Social worker	+ .30
Accountant	− .03
Business executive	− .03
Industrial manager	− .03
Personnel director	− .18
Sales manager	− .25
Office supervisor	− .29
Retail store manager	− .29

When the full range of occupation profiles is considered, the scientist and the engineer have a good deal in common. In terms of strength and competence, as indicated by middle values on such items as *active, confident, strong, hard, self-assertive*, and *realistic about life*, they have very similar scores. Competence in either field connotes a reasonable degree of success, social status, and power in public affairs. The scientist differs from the engineer in that he is believed to be more intellectual and less conformist in personal behavior and political viewpoint. The scientist also is rated higher than the engineer in concern with esthetic matters, in spite of the relatively low rating of the scientist in the realm of cultural interests. The scientist is considered more persevering, self-sacrificing, and valuable to society, as well as more interesting and colorful. On the other hand, the engineer has two clear advantages over the scientist. First, the engineer is more concerned with people. He is a sociable, popular fellow as compared with the scientist. Secondly, the engineer is considerably wealthier, and he is a more "regular guy" than the scientist. This latter characteristic is indicated by the higher scores for the engineer on *clean cut, plays poker*, and *has good taste* (taste in clothes, house, car, and so on), and the engineer is believed more likely to have a pretty wife. In conclusion, then, the engineer is thought to be less of an "egghead" than the scientist. He is less intelligent, less nonconforming, less sensitive esthetically, and less valuable to society. At the same time, the engineer

is a more normal, healthy American male, with somewhat the same traits of character as the scientist but with little of the scientist's tendency to go to extremes in behavior or emotional commitment. To summarize, engineers are "Simonized scientists," to bend a phrase recently reported in a national magazine.

Relation of Experience to Image

The student responses were analyzed to determine whether the life experiences and current status of the students were associated with different beliefs about occupations. It was found in comparing the scientist image held by men with that held by women and the image held by students in private as against public colleges, by freshmen as against seniors, by students from different socioeconomic backgrounds, by students from professional as against business families, and by students from different types of communities, that these groups do not differ in their beliefs about the scientist. This is clearly a stable image that is shared widely among college students with varied histories and experience.

In a study parallel to the one under consideration, 41 entering Wesleyan freshmen who indicated an intention to become scientists were compared with all the freshmen who planned to be active in other careers (*8*). Those who intended to be scientists had a more favorable image of both the scientist and the engineer than the remainder of the newly arrived freshmen. The would-be scientists, as compared to the other freshmen, viewed the scientist as more colorful and interesting, of higher social status, more successful, more sensitive to art, and of a more sociable temperament. In absolute terms, the men wishing to enter the field of science rated the scientist quite high in material and social success and in esthetic interests, while they considered him moderately concerned with people. The scientist, as seen by these students, is interesting and colorful. Moreover, as compared with the non-science students, the science students had an image of the engineer that was closer to their image of the scientist. They viewed the engineer as more individualistic, persevering, and capable of deriving satisfaction from his work than did non-science students. In general, the engineer was seen as being more a man of parts by the pre-science students.

There is also evidence in the data that students on entering college have a more favorable view of the scientist than students who have already spent a semester in college. The new students have a more favorable view than second-semester freshmen of the intellectual ability, artistic concern, and success of the scientist.

Faculty Members' View

A group of 27 college teachers of science at Wesleyan University were asked to respond to the same questionnaire that was given to the students. These men were a random sample of the science faculty. It is quite clear that the word *scientist* has similar connotations for them and for students. There was a correlation of +.91 between the average values attributed to the scientist by the Wesleyan students and by members of the science faculty on a group of 21 scales to which responses were made by both groups. The main differences between the two groups were, first, that the students attributed much more influence in public affairs to the scientist than the science teachers did, and, second, that members of the science faculty saw the scientist as more interested in art. Otherwise, the two groups were in close agreement.

Within the ranks of college teachers at Wesleyan, members of science and of social-science faculties are in almost complete agreement on the scientist image. On the other hand, faculty members in the humanities are more complimentary to the scientist than are the teachers of science or social science. A random sample of 23 teachers of the humanities rated the scientist quite high in material and social success and considered him more calm and more sociable than the science teachers did. The worldly success of the scientist seemed more impressive to teachers of the humanities than it did to teachers of the sciences.

Occupational Preferences

Students participating in the main study were asked to indicate the degree to which they would like to enter each of the 15 occupational fields if barriers related to expense, length of training, and native ability were removed. In other words, a male student was directed: "rate each occupational position in terms of how much you would like to be in it if you could be in any occupation you wanted." The data revealed that a group of four occupations —those of college professor, lawyer, doctor, and business executive—were considered most desirable, in that order. The occupations of scientist and school teacher came next in order in a second grouping, at some distance from the first. A rather large gap appeared between this and the next grouping, the occupations of engineer and personnel director. When women were asked to estimate the attractiveness of these occupations for men, they also ranked the scientist in the fifth position. However, when college women were asked to name the single occupation for a future husband that would be most pleasing to them, only 3 percent indicated scientist. Approximately 20 percent of the women wished their husbands would be doctors, and another 20 percent selected the profession of lawyer.

Stereotypes of Specialized Scientists

In studies of the ranking in prestige of professions and occupations, the ranking of the term *scientist* differs from that of terms such as *chemist* or *biologist*, which describe scientists in specific fields (*9*). In view of this finding, an exploratory study was designed to elicit the images of biologist, chemist, and physicist (*10*). A small number of Wesleyan students were asked, in an interview, for their impressions of the personality, family life, status, social life, and motivations of men in each scientific field. Although the sample was small and unsystematically chosen, the agreement among students was so great as to suggest that the findings are of general significance. The stereotype of the specialized scientist in each case was more favorable than the image of scientist that was revealed in other interviews. According to these stereotypes the scientists in designated fields are more wealthy and successful, have richer social lives and more rewarding family lives, and are more pleasant and outgoing people than the "scientist" considered apart from his field. The biologist is the most normal of the scientists in the sense that he approaches most closely the American ideal, and to the physicist are attributed many of the negative qualities that emerged in the interviews concerned with the generalized "scientist." The chemist falls between the two extremes.

Conclusions

These data suggest that there exists among college students a readiness to respond to the word *scientist* in a complex and differentiated manner. There is wide agreement concerning the image of the scientist among various classifications of men and women students in the Northeast. Members of one college faculty share this image with their students. The image is the same for freshmen as for seniors. It is safe to assume that the outlines of the image are the same for students at many colleges and for many college-educated adults. It is quite likely that the image is shifted somewhat in the first few months of a student's college career, but it is obviously not markedly changed. The image of the scientist among college students resembles in many ways the image held by high school students, as reported by Mead and Metraux (*2*).

The specific features of the scientist image are important for several reasons. First, the image reveals the students' beliefs about the personality of the scientist and the style of life associated with a career in science. It means to the potential recruit that, if he selects science, he should have a certain set of personal qualities and can expect a particular kind of social life and certain types of personal associates, and it implies that the kind of life he will live is greatly limited by his work. If these features of the life of the scientist do not fit with the student's beliefs about himself or his hopes for the future, he is likely to be wary of committing himself to a career in science. At the same time, of course, the image influences the behavior of the student who has chosen science and leads him to develop those aspects of his character most in keeping with the stereotype of the scientist.

In short, the image has the effect of recruiting a certain type of person and discouraging others. This limits the range of people likely to consider the field, and it restricts the variety of basic talents available to science. Second, the public reaction to science, scientists, and the contributions of scientific research is likely to be colored by this image. This is particularly true in areas where arguments center around the generalized role of science. For example, the role of scientists in government or the advisability of admitting scientists to positions of high responsibility are issues frequently discussed in general terms. It may even be that the negative reaction of college students to courses in "general science" is attributable in part to the attitudes tapped by the word *science*.

The strong features of the image of the scientist are his high intelligence and his driving concern to extend knowledge and to discover truth. His work is of great value to mankind, and it brings him both a sense of satisfaction and a fair measure of success. The weaknesses in the image are many and disturbing. The scientist is seen as basically uninterested in people and unsuccessful with them. To the contemporary student, a person who does not care for people is suspiciously out of touch with life. The scientist is not interested in art—he has eschewed the life of the spirit that gives breadth and vitality to the life of the mind. Further, the scientist is a nonconformist and a radical, as well as a person with only moderate control of his impulses. These features suggest that college students possess beliefs that can easily be played upon to indict the scientist in times when loyalty is an issue of public concern. The undesirable aspects of this picture of the personal and intellectual life of the scientist make the role hard to accept in spite of the attractiveness of the work and the social contributions of the scientist.

The attractiveness of a scientific career in an abstract sense is clearly indicated by the high rank given it by men in statements concerning what they would like to be. Yet, surprisingly, few women wish to marry a scientist. It must be that, for men, the intellectual status, success, and material well-being of the scientist outweigh the many disadvantages of the scientist image. On the other hand, a woman married to a scientist must accept his personal qualities while benefiting very little in a direct way from the nature of his job.

Students clearly prefer the personality, social opportunities, and style of life of the college professor to those of the scientist. The scientist's only asset, by comparison with the professor, lies in the rewards associated with the work, and the differential is not great. The engineer and the scientist offer relatively interesting alternatives. The scientist is seen as an intellectual, with little capacity for social interchange; the engineer is a more normal "organization man," aiming at a nine-to-five existence, with an interest in good fellowship. It would seem that a student of science who could achieve the requisite training would be strongly drawn to college teaching with its richer, more humane connotations. On the other hand, the attractions of science and of engineering would seem to balance, with a person's view of himself playing an important role in his choice of one or the other.

It is interesting that students intending to pursue careers in science should have a more favorable image of the scientist than their colleagues who are planning other careers. It is not known whether commitment to a field changes the image or whether those with a more favorable image are drawn to the field. Probably both of these processes contribute to this difference.

It is comforting to find that scientists who are identified with their particular specialties are perceived as relatively normal people. These findings indicate that monolithic "science" is a source of concern to many sensitive citizens. On the other hand, men with professional specialties are considered more human, loyal, and comprehensible than "the scientist."

Science as a Way of Life

The standard contemporary response to the finding that a product presents a "bad" image to the public is to turn for assistance to a team of public relations men who are instructed to change the image. To change an image as well developed and as widespread as the image of the scientist appears to be a most discouraging undertaking. This image is imbedded in a system of other stereotypes with which people, even highly educated people, structure their social world. To eliminate the unfavorable connotations from *scientist* would require a brilliantly conceived long-term campaign of confrontation through mass media and of educational innovation that is not likely to be undertaken. But is a massive campaign to alter this image appropriate? Scientists themselves, as well as their faculty colleagues, agree upon the essential features of the image. If it does represent, even in a distorted and exaggerated fashion, the characteristics of American scientists, it may be that to use publicity techniques would not only fail to hide the reality that lies behind the image but might also be dishonest.

Our studies give no data as to the actual (as distinguished from the perceived) characteristics of scientists. Yet C. P. Snow (*11*) has argued that indeed

scientists *are* less interested than most educated men in esthetic matters and social affairs. Perhaps "the discipline" of science *does* narrow a man's interests, does create a group who do not meet the cultural ideal of the broadly educated man. If so, the "solution" is not to be found in an aping of Madison Avenue but, as Snow has also argued, in a more general appreciation on the part of the intellectual community of the demands the scientific mode of thought makes upon anyone, professional scientist or not, who seeks an objective understanding of the world around him. Perhaps, also, scientists have "over-conformed" to their own image of what a scientist is, and perhaps the reality can change as more of them develop the broader interests and cultural appreciation constantly called for by liberal educators.

A final stance for the scientist consists in recognition of the possibility that to be a scientist is indeed to be different. The studies of Roe (*12*) and of Thorndike and Hagen (*13*) have shown that scientists tend to have characteristic developmental histories and personality structures. It may be that in order to do their work, recruits to scientific careers require some of the qualities which, in extreme form, appear in the stereotype of the scientist. If so, cannot the scientist accept this and get on with his work?

References and Notes

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2. M. Mead and R. Metraux, *Science* **126**, 384 (1957).
3. E. W. Harbinger and A. LaCava, Wesleyan undergraduates, assisted us in this study. The research was carried out under a contract with the U.S. Office of Education, Department of Health, Education, and Welfare. Additional support was provided by the Faculty Research Committee of Wesleyan University.
4. The occupations that were studied are listed in Table 1.
5. The form of the questionnaire and some of the scales are taken from the work of C. E. Osgood [for example, C. E. Osgood, G. J. Suci, P. H. Tannenbaum, *The Measurement of Meaning* (Univ. of Illinois Press, Urbana, 1957)].
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Science in the News

The Budget: Kennedy Asks for Science Increases beyond the Increases Ike Recommended

The Kennedy budget recommendations include substantial increases for scientific research, which come on top of the already substantial increases provided in the final Eisenhower budget. In both cases, on a percentage basis, the increases are sharpest for basic research.

Eisenhower recommended an increase of nearly $800 million for overall research and development. This was an increase of about 9 percent, and about 4 times as great a percentage increase as he recommended for federal spending in general. Of the science increase, about $200 million was for basic research, which is a 25 percent increase over the $810 million being spent in the current year and, of course, about 12 times as great a percentage increase as he recommended in overall federal spending.

The details of the Kennedy budget are not all available at the time of this writing. But the over-all increase, exclusive of that for defense research and development, where figures were not available, amounted to around $150 million, with the largest gains for space, oceanography, the National Institutes of Health, and the National Science Foundation.

The National Science Foundation increase, almost all of it for basic research, is $29 million, which comes on top of a $39 million increase already recommended by the Eisenhower budget. This is about a 65 percent increase for the agency, whose research budget last year was just under $90 million. How much of this increase survives the Congressional budget review will offer a fair test of the new Administration's effectiveness in selling Congress on the idea of more support for basic research.

Basic Research and Congress

The difficulty of arousing Congressional enthusiasm for basic research showed up in what happened to Eisenhower's budget requests last year. The following figures, unlike others in this report, are for new obligational authority rather than actual spending. (Congress might, for example, appropriate $100 million in the fiscal 1962 budget for a project that will take 3 years to complete: actual spending in fiscal 1962 might be only $35 million; the rest would be spent in fiscal 1963 and 1964. The figures are for obligations, that is, they include such things as orders placed which will not be filled and paid for until a later year. Actual spending is somewhat less.)

Eisenhower last year requested just under $8 billion for research and development for fiscal 1961, which ends this June. This was a slight decrease from the previous year. Although Congress, as it always does, cut the overall budget requests of the President, it did the opposite with research and development. It gave the President $554 million more than he had asked for. But this increase did nothing for basic research: here Congress cut Eisenhower's requests back from $880 million to $850 million.

In the Defense Department, basic research was not cut, but it received no share in the increase (nearly $500 million) Congress added to the budget for research and development. In the National Institutes of Health, where basic research makes up about a quarter of the research budget, Congress added $4 million for basic research,

$85 million for applied research. The National Science Foundation, which supports only basic research, had its research budget cut from $84 million to $76 million. The Space Agency got $58 million above Eisenhower's request for applied research and development, but its basic research was cut $20 million.

What this suggests is that Congress has to be sold on proposals for basic research, while it is quite ready to provide money for applied research and even readier to provide money for development. The reason, of course, is that the more specific you can be about what you are getting for your money, the more money you can get, and basic research, by definition, is that area where you cannot be specific about what you are getting for your money.

The figures show no general antagonism in Congress to basic research: basic research suffers only in comparison with what Congress is willing to spend on applied science and technology, but the cuts in requests for basic research funds are no greater than those Congress normally makes in the President's budget.

Attitudes of Congressmen

Ten years ago it would have been quite easy to find influential members of Congress who would have responded to a question about basic research with a blank look. Today it is just about impossible to find a Congressman of any influence who cannot give a reasonably coherent definition of basic research and of why it is something to spend money on.

Congressman Albert Thomas of Texas, who uses his power as chairman of a House appropriations subcommittee to regularly cut the research budget of the National Science Foundation, which comes under his review, is the special bane of supporters of basic research. Thomas is unenthusiastic about government spending in general. But when asked recently about the value of basic research he replied: "Basic research is the only *real* research; the rest is just applications. We realize that on a day-to-day basis it looks like you're throwing money in a rat hole, but comes some Saturday night and the whole thing pays off." This is not quite the way James Conant might phrase it, but it is a long way from former Defense Secretary Wilson's "Basic research is when you don't know what you're doing."

Nevertheless, the fact remains that the area where the scientific community would most like to see increases is exactly the area where it is most difficult to get Congress to accept increases, and this despite the fact that basic research projects are generally far cheaper than other types of research projects.

The Budget Message

Shortly after Eisenhower presented his last budget, just before Kennedy's inauguration, the *Wall Street Journal* ran an analysis of it which called it a "political joke on the incoming Administration," meaning that the budget, although on paper it showed a $1.1 billion surplus, was in fact almost certain to produce a deficit even if Kennedy added nothing to it. This meant that Kennedy, even if he forgot all his campaign talk and introduced no new programs, would still be liable to a charge that he took over a balanced budget from the Republicans and was somehow responsible for unbalancing it.

Kennedy, with feats of logic that would delight Lewis Carroll, carries this game to a new level. He cites his pledge in his State of the Union Address that "barring the development of urgent national defense needs . . ." his programs would not "of and by themselves unbalance the earlier budget." In the context of the message the "urgent defense needs" referred, quite clearly, to actually new needs, rather than the needs that Kennedy and many other people have been talking about for over a year.

But the budget message shifts this ground quite deftly. All increases in defense spending are now assumed to be urgent new needs, and therefore the determination as to whether the new Administration is trying to balance the budget is to be made solely on the basis of what it is doing about nondefense spending. This is the first step.

Kennedy then demonstrates that *if* Eisenhower's budget were accurate and *if* defense increases are not to be counted, then his budget *would* be balanced. *Therefore* the new Administration can be supported by right thinkers, who realize that no Administration could deliberately unbalance the budget and at the same time retain any claim to fiscal responsibility.

In fact, of course, the Administration had decided on a deficit in order to stimulate the economy—a course that is considered eminently sound and responsible by most of the country's economists. The more serious portions of the message make this fairly clear, and a recent lengthy report from the Council of Economic Advisors to the Congressional Joint Economic Committee offered a detailed account of the reasoning behind the Administration's policies, although the less palatable notions were never put into blunt enough language to mean much to someone without some familiarity with economics.

This is the heart of the curious nature of the budget message. Anyone who has mastered an introductory course in economics has no reason to be confused about what the Administration is doing. He may not agree, but he should not be confused. The less popular notions are expressed in technical language, but it does not take a Ph.D. in economics to translate "stimulate demand" into "spend more money."

The message makes perfectly clear that Kennedy anticipates a deficit of $2.1 billion from his domestic program plus $2 billion from the defense program, for a total deficit of about $4.1 billion. For the rest, the message is simply taking advantage of the public's lack of sophistication.

The lack of any great public outcry about Eisenhower's five unbalanced budgets, not even about the record $12.5 billion deficit in fiscal 1959, suggests that the public does not really expect the budget to be balanced at the end of every year. This does not prevent the public from expecting its elected officials to talk about a balanced budget at the beginning of every year. And as long as political leaders must talk about balanced budgets in order to maintain their popular support, they do not have much choice but to do so.

The largest single category of nondefense increases was for education. Here the net increase (some Eisenhower programs were replaced by Kennedy programs for the same purpose) was over $500 million. The science increases, while not as great, were given special emphasis in the budget message, and seemed satisfactory to people concerned with science policy. Budget officials said that the Administration had gone out of its way to fit in as much extra money for science as possible, within both the limitations of the size of the budget and the limited num-

ber of changes that it was possible to make in the Eisenhower budget. (Making the budget is a year-round job. The new Administration is limited in its budget changes by the limited amount of time that it has to review the budget before Congress must begin to act on it.)

How many of the recommendations will actually get through Congress, and how much room there will be in future budgets for similar program expansions, depends in large part on how successful the Administration is in winning support, or at least acceptance, of its over-all economic policies. The necessity and difficulty of winning this support made the budget message the most peculiar thing of its kind the American public has ever had occasion to ponder—H.M.

News Notes

Page Charges in Biological Journals

The Conference of Biological Editors at its 1961 annual meeting studied, in both a work session and a general session, the matter of page charges by biological journals of primary publication. (Page charges were defined as partial costs of publication of a paper, payable not by the author but by the institution, or from the fund, that supports his research.)

Among the factors which have led to consideration of page charges are the following.

1) Support of research by federal and private funds since World War II has enormously increased the amount of material to be published, but the number of journal subscribers has not increased proportionately, partly because of increased subscription prices.

2) Still higher subscription prices militate against wider circulation to individuals and impose severe hardships on institutional and library budgets, which have not benefited directly from the availability of federal and private grants for research. Such hardships and deterrents to circulation are even more acute abroad than in this country.

3) On any but a temporary basis, direct government subsidy to *selected* journals is undesirable, and direct support of *all* seems impracticable or unnecessary. Indirect subsidy, through payment of page charges, leaves wide freedom of choice to individuals as to which journals to support by submission of their research papers for publication.

4) Several journals of the American Institute of Physics have satisfactorily used a system of page charges for 25 years or so. Other journals, including a few in biology, have had satisfactory experience with the system over a shorter period. During this time federal policies and public laws have been modified explicitly to permit the payment of page charges from federal research grants as well as from appropriations to government laboratories.

5) For many years it has been common practice for journals to charge "excess publication costs" for tables, engravings, formulas, color, or text pages beyond a stated maximum. Such a policy rewards brevity but tends to restrict arbitrarily the coverage of a report. Moreover, it encourages the practice of fragmenting a research report into several papers, which, together, cost more to publish and are less effective than a single, more extensive, paper.

6) Editorial appraisal of the scientific merits of a paper should be divorced from any questions of cost and charges. Journals of the American Institute of Physics and of certain other societies have accomplished this by deferring any inquiry as to whether or not page charges will be accepted by an author's institution or payable from his research funds until after the paper has been accepted for publication.

A summary statement of guiding principles adopted by the conference, whose membership includes the editors of more than 100 biological journals, is as follows.

Publication is recognized as an essential step in the completion of research. That a portion of publication costs should be borne by research budgets is a corollary of this principle. The CBE considers that a system of page charges, adequately safeguarded to eliminate financial considerations from scientific evaluation of papers, is an acceptable and desirable means for supplementing journal income.

Many systems differing in detail may be devised, but common to all should be these provisions: that the charge should be substantially less than the full cost of publication; that the charge should not be payable by the author personally, but by his institution or the funds that support his research; and that the charge should be imposed only if the author's institution or his supporting funds are able to accept it.

News Briefs

Nuclear power costs. The Atomic Energy Commission has published a 40-page, revised version of *Costs of Nuclear Power*. The pamphlet is available from the Office of Technical Services, U.S. Department of Commerce, Washington 25, D.C., for 50 cents a copy. It includes information on several new reactor projects, and the text and tables have been revised and expanded to include new data that became available during the third quarter of 1960.

The report has nine major section headings: research and development costs, construction costs by major categories, total construction costs, working capital, annual fixed charges, fuel-cycle costs, cost of operation and maintenance, total generating costs, and objective for competitive nuclear power in the United States. Data on foreign installations are given when they are available; the report gives figures for 30 foreign nuclear power plants and for 22 plants in the United States.

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U.S.-Mexican engineering program. The University of Wisconsin's College of Engineering and the Mexican Institute of Technological and Advanced Studies at Monterrey, Mexico, will cooperate in an unusual program for training American engineering students at the Mexican institution during the next 2 years. The program is the first of its kind to be undertaken by the United States and Mexico. It was made possible by a $100,000 grant from the Carnegie Corporation of New York. The funds will support a junior-year program for Wisconsin engineering students at the Instituto Technologico y de Estudios Superiores de Monterrey. The first year's program is to be a pilot study, involving only University of Wisconsin students. The program may be extended to other universities later.

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Bottles measure ocean flow. Some 30,000 bottles, bobbing on the ocean for more than 3 years, have provided the Pacific Oceanographic Group of the Fisheries Research Board of Canada with data on the circulation of the Northeastern Pacific and Bering Sea.

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Number of diabetics increases. The number of diabetics in the United States has increased greatly in recent decades, the Metropolitan Life Insurance Company reports. There are about 1.5 million known cases of diabetes in this

country, according to data derived from the current U.S. National Health Survey. This is equivalent to 9 per 1000 population. The number of diabetics now is more than double that in 1937, as estimated from the first National Health Survey. The increase is largely due to population growth and to the greater longevity of diabetics.

The new survey indicates that diabetes is about 1⅓ times as frequent among females as among males for all ages combined. The large majority of diabetics of both sexes are past middle life; more than 80 percent are 45 or older, and nearly 40 percent are 65 and over.

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Soviet physics. The American Institute of Physics has announced that its bimonthly publication, *Soviet Physics-Doklady*, which offers brief reports on Russian research in the whole range of pure and applied physics, will appear monthly, starting with the July issue (vol. 7, No. 1). The journal is a translation of the physics sections of *Doklady Akademii Nauk S.S.S.R.* (the *Proceedings* of the Academy of Sciences of the U.S.S.R.).

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Nonmetallic crystals. An international symposium on the chemical physics of nonmetallic crystals will be held 28–31 August at Northwestern University, Evanston, Ill. The symposium is sponsored by the divisions of chemical physics and solid state physics of the American Physical Society and the division of physical chemistry of the American Chemical Society. The principal objective of the meeting is to survey the knowledge of binding in nonmetallic crystals and the equilibrium properties of point defects (chemical and structural) in these crystals.

The program will consist of both invited and contributed papers; these will be published collectively, either in an issue of a scientific journal or in an independent volume. Abstracts of prospective contributions should be sent *before 1 May* to the chairman of the program committee, Professor W. J. Moore, Department of Chemistry, Indiana University, Bloomington, Ind.

Grants, Fellowships, and Awards

Biometry. Training programs designed to prepare students in the application of statistical and mathematical methods to biological problems, particularly those related to health and medical sciences, now exist in more than 20 universities throughout the country. Supported by training grant funds from the Public Health Service, National Institutes of Health, these programs provide unusual opportunities for careers in teaching, research, and consultation.

Programs of study are individually designed to lead to doctoral degrees and, in special instances, to other academic degrees. Traineeship stipends are provided at various levels, depending on the education and experience of the trainee, and include allowances for dependents.

Interested individuals are encouraged to correspond with one or more of the 20 program directors, a list of whom may be obtained from Emmarie C. Hemphill, Executive Secretary, Advisory Committee on Epidemiology and Biometry, Division of General Medical Sciences, National Institutes of Health, Bethesda 14, Md.

For those with no time for training during the academic year, an unusual opportunity is provided by a cooperative Graduate Session of Statistics in the Health Sciences, sponsored by the 20 program directors and made possible by a training grant from the Public Health Service. For information concerning available stipends and course offerings at elementary, intermediate, or advanced levels for the summers of 1961 and 1962, write to Dr. Jacob E. Bearman, University of Minnesota, Minneapolis, Minn.

History of science. The History of Science Society has announced the 1961 Ida and Henry Schuman Prize contest in the history of science. The annual award of $250 was established by Henry and Ida Schuman of New York City for an original prize essay in the history of science and its cultural influences. The competition is open to graduate and undergraduate students in any American or Canadian college, university, or institute of technology. Papers should be approximately 5000 words in length, exclusive of footnotes, and should be thoroughly documented. It is hoped that the prize-winning essay will be suitable for publication in *Isis*.

Papers should be sent *by 1 July* to the chairman of the prize committee, Professor Edward Grant, Department of History and Logic of Science, Indiana University, Bloomington, Ind.

Life sciences. The Division of Biological and Medical Sciences of the National Science Foundation has announced that the next closing date for receipt of basic research proposals in the life sciences is *15 May*. Proposals received prior to that date will be reviewed at the summer meetings of the foundation's advisory panels, and disposition will be made approximately 4 months after the closing date. Inquiries should be addressed to the Biological and Medical Sciences Division, National Science Foundation, Washington 25, D.C.

Mental health. The fellowship program of the National Institute of Mental Health provides support for training in mental-health research leading to an understanding of human behavior, normal and abnormal. The program gives wide latitude both in the selection of a field of study and in the research approach. Work may be in the medical, biological, psychological, and social sciences; it may be basic or applied, clinical or nonclinical; and it may be in such areas as mental retardation, juvenile delinquency, aging, and alcoholism.

Fellowships are awarded on three levels—predoctoral, postdoctoral, and special. Applications may be submitted at any time. However, for review next fall, completed forms should be returned *before 1 August*. Notification of action is usually made within 4 months. For detailed information write to: Dr. B. E. Boothe, Chief, Research Fellowship Program, Research Grants and Fellowships Branch, National Institute of Mental Health, Bethesda 14, Md.

Pharmacology, travel. The Section on Pharmacology, International Union of Physiological Sciences, has received a grant from the National Institutes of Health to pay travel expenses for U.S. scientists who attend the First International Pharmacological Meeting in Stockholm, 22–25 August. Part of the fund will be used to cover passage of the invited American participants and of the members of the U.S. National Committee of IUPS. The rest of the grant will be awarded to scientists who have a particular interest in the general program.

Applications should be submitted in triplicate *before 1 May* to Dr. Carl F. Schmidt, President of the IUPS Section on Pharmacology, Department of Pharmacology, University of Pennsylvania, School of Medicine, Philadelphia 4, Pa. Full name, age, address, nationality, earned degree or degrees, academic affiliation, membership in any biological society, and field of research should be stated in the applica-

tion. No one who holds a government or private grant which allows travel funds should apply.

Scientists in the News

Martin Schwarzschild of Princeton University has won the Henry Draper Medal of the National Academy of Sciences for his work in stellar evolution. The medal, established in 1883 to recognize significant contributions to astronomical physics, will be presented at the annual meeting of the academy in Washington on 24 April. A professor of astronomy at Princeton, Schwarzschild has written some 33 papers on the internal composition and evolution of the stars and related astronomical subjects.

He is widely known as the director of Project Stratoscope, in which the surface of the sun was photographed from an unmanned balloon at about 15 miles above the earth's surface. Rising clear of 96 percent of the earth's turbulent atmosphere, the telescope-camera unit was self-aimed under the control of light-sensitive semiconductors, and it produced the sharpest photographs ever taken of the granulation and pore structure of the sun's surface. Analysis of the data obtained from these pictures contributed toward an understanding of the mechanisms of heat transfer from the center of the sun to its surface. For this work Schwarzschild and two of his colleagues received in 1957 the AAAS Newcomb Cleveland Prize. A second project, Stratoscope II, is now in progress.

Martin Schwarzschild. [O. J. Turner]

Eight Nobel Prize winners will gather at Columbia University on 11 April to receive the Alexander Hamilton Medals for 1961. The Hamilton awards are presented annually by the Association of the Alumni of Columbia College to alumni or faculty members for "distinguished service in any field of human endeavor."

The 1961 recipients are as follows.

Edward C. Kendall, Nobel Prize in physiology and medicine, 1950; professor of chemistry at Princeton University.

Polykarp Kusch, Nobel Prize in physics, 1955; professor of physics at Columbia.

Willis Lamb, Nobel Prize in physics, 1955; professor of theoretical physics at Oxford University.

Joshua Lederberg, Nobel Prize in physiology, 1958; professor of genetics at Stanford University.

Hermann J. Muller, Nobel Prize in physiology, 1946; professor of zoology at Indiana University.

John H. Northrop, Nobel Prize in chemistry, 1946; professor emeritus of bacteriology at the University of California.

I. I. Rabi, Nobel Prize in physics, 1944; professor of physics at Columbia.

Harold C. Urey, Nobel Prize in chemistry, 1934; professor of chemistry at the University of California.

The following awards were presented during the recent annual meetings of the American Physical Society and the American Association of Physics Teachers, held in New York.

Walter Kohn of the School of Science and Engineering at the University of California, La Jolla, received the 1961 Oliver E. Buckley Solid-State Physics Prize of the APS "for his extension and elucidation of the foundations of the electron theory of solids." Funds for this prize have been provided by Bell Telephone Laboratories.

Jerrold R. Zacharias of Massachusetts Institute of Technology received the Oersted Medal of the AAPT for his efforts to improve the teaching of physics in U.S. high schools, particularly through his work in organizing and directing the Physical Science Study Committee in Cambridge.

The AAPT Distinguished Service Citations for notable contributions to physics education in the United States were presented to **Thomas B. Brown**, a member of the faculty of Harvey Mudd College and professor emeritus at George Washington University; **Walter C. Michels**, professor of physics at Bryn Mawr College; **Eric Rodgers**, chairman of the department of physics at the University of Alabama; and **Yale K. Roots**, of the U.S. Naval Propellant Plant, Indian Head, Md.

The winners of the AAPT physics apparatus competition, which was supported by a grant from the Central Scientific Company, were as follows.

The first prize in the undergraduate laboratory category, for $500, went to **Erwin W. Mueller**, of Pennsylvania State University, for a field ion microscope.

The first prize, for the same amount, in the lecture demonstration area was won by **Walter Eppenstein**, of Rensselaer Polytechnic Institute, for his design of bread-boards for the display of electrical circuits by an overhead projector.

Second prize ($200) in the laboratory category was awarded to **Charles Zucker**, of Fairleigh Dickinson University, for a wire method of measuring the magnetic field.

A prize of $200, second prize in the lecture demonstration classification, went to **Paul Whiting**, of the University of Minnesota, for his demonstration of conservation of momentum in an hourglass system.

Winners of third place, with prizes of $100, were **John G. King**, of the Massachusetts Institute of Technology, for a molecular beam apparatus, and **H. V. Neher**, of California Institute of Technology, for a lecture demonstration on light pressure.

John S. Foster, Jr., associate director of the University of California's Lawrence Radiation Laboratory, Livermore, has been appointed director of the laboratory, effective 1 June. He replaces **Harold Brown**, who was recently named by President Kennedy to the position of director of defense research and engineering for the U.S. Department of Defense.

Winston M. Rodgers, senior principal scientific officer of the Industry Division, Department of Scientific and Industrial Research, London, will be in this country from late April to July, studying operations research and statistics at the managerial level.

Warren C. Johnson, vice president of the University of Chicago and professor of chemistry, has been named to receive the Atomic Energy Commission Citation. He retired last year, as chair-

man of the AEC's General Advisory Committee, a post he had held for 4 years. Johnson also served as chairman of the commission's Board of Senior Reviewers from 1949 to 1956. He is being honored for meritorious service in advancing the atomic energy programs of the commission and of the United States.

Johnson is the second recipient of the AEC Citation, which was established in 1960 to honor persons not in the employ of the commission. The citation, accompanied by a symbolic medallion, will be presented in a ceremony in Washington, D.C., late in April.

Nine U.S. scientists who received 1960 Borden Awards of a gold medal and $1000 for outstanding research achievements are listed in an annual directory just released by the Borden Company Foundation, Inc. A total of 179 awards has been made by the foundation since the program began in 1937. The awards are administered by professional and scientific associations. The administering groups and the 1960 award winners, with summaries of their principal contributions, follow.

American Chemical Society. **Eugene L. Jack**, professor of dairy industry, University of California, for his studies on the composition, structure, physical properties, and nutritional values of milk fat.

American Dairy Science Association. **Norman L. Jacobson**, professor of dairy husbandry, Iowa State University, for his research contributions to dairy animal nutrition, including work on utilization of carbohydrates by dairy animals and the effects on dairy cattle of feed treated with antibiotics.

American Dairy Science Association. **Mark Keeney**, professor of dairy manufacturing, University of Maryland, for a number of significant research contributions on the chemistry of butterfat.

American Home Economics Association. **Marian E. Swendseid**, associate professor of nutrition and physiological chemistry, University of California, for her research in vitamin and protein nutrition.

Association of American Medical Colleges. **Robert F. Pitts**, professor and chairman of the department of physiology, Cornell University Medical College, for his fundamental contributions to an understanding of renal tubular functions.

American Institute of Nutrition. **R. Gaurth Hansen**, professor and head of the department of agricultural chemistry, Michigan State University, for a series of studies, in the general fields of biochemistry and nutrition, that have contributed to a clearer understanding of the nutritional role of milk sugar.

American Academy of Pediatrics. **Harold E. Harrison**, pediatrician-in-chief, Baltimore City Hospital, and associate professor, Johns Hopkins University School of Medicine, for his fundamental research on vitamin D and its role in the regulation of the transport of calcium and phosphorus.

Poultry Science Association. **Frederick W. Lorenz**, professor of poultry husbandry and poultry physiologist in the Experiment Station, University of California at Davis, for research contributions that are basic to the use of estrogens in poultry production and to artificial insemination in turkeys.

American Veterinary Medical Association. **Henry H. Dukes**, professor emeritus of veterinary physiology, Cornell University, for his studies in the general area of animal physiology, which have served as a starting point for many investigations into the metabolic diseases of cattle. He was also cited for his long and productive career as a teacher and trainer of research workers.

Donn Rosen has been appointed assistant curator in the department of ichthyology at the American Museum of Natural History, New York. For the past year he has been with the University of Florida at Gainsville, where he held the posts of assistant professor of biology and assistant curator of biological sciences at the university's Florida State Museum.

Werner K. Weihe, chief of the Far Infrared Branch at the U.S. Army Engineer Research and Development Laboratories, Fort Belvoir, Va., has been named executive editor for the United States for *Infrared Physics*, an international research journal to be published by Pergamon Press, Ltd., England. Other editors of the new journal include M. Migeotte of Belgium, T. S. Moss of England, Sidney Passman of the United States, and an international editorial board. A regional editor for the U.S.S.R is to be appointed.

Margaret H. Sloan, National Blood Program executive and staff director of a recent medical research study for the Senate Appropriations Committee, has been appointed special assistant to the director of the National Cancer Institute. She will be active in program development, particularly in the international field. Dr. Sloan has earned international recognition for her service as assistant director and later director of advisory services to the National Blood Program of the National Academy of Sciences–National Research Council, which she joined in 1950.

Recent Deaths

M. Hillel Feldman, New York, N.Y.; 72; dentist who was a pioneer in oral surgery; in 1917 organized the dental department at Lincoln Hospital, where for many years he trained interns in oral surgery; wrote the textbook *Exodontia*; 1 Mar.

James O. Foley, Birmingham, Ala.; 64; since 1947 professor of anatomy at the University of Alabama Medical Center; a former department chairman, he was associate dean of the Medical College from 1951 to 1956; 28 Feb.

Irving Hyman, Buffalo, N.Y.; 52; chief of neurology at Buffalo General Hospital and chairman of the neurology department at the University of Buffalo Medical School; 7 Mar.

Asa S. Kinney, South Hadley, Mass.; 87; associate professor emeritus of botany at Mount Holyoke College; 2 Mar.

Philip Schwed, Baltimore, Md.; 38; research physicist at the Research Institute for Advanced Studies (1956–1961); principal scientist in the institute's cosmic radiation program; conducted theoretical studies in particle and solid-state physics; formerly with Lewis Laboratory; 2 Feb.

Joseph C. Turner, New York, N.Y.; 51; professor of medicine at the College of Physicians and Surgeons of Columbia University; director of the Clinical Pathology Laboratories and head of the hematology clinic at Columbia-Presbyterian Medical Center; author of a textbook on clinical pathology; 2 Mar.

Carl J. Warden, De Land, Fla.; 70; former professor of psychology at Columbia University; headed the animal psychology laboratory at Columbia for some years, later had charge of the Laboratory of Comparative Psychology and dealt largely with human psychology; wrote *The Emergency of Human Culture* and served as associate editor of the *Journal of Genetic Psychology*; 28 Feb.

Book Reviews

American Foreign Policy Since World War II. John W. Spanier. Praeger, New York, 1960. 234 pp. Paper, $1.75; cloth, $4.50.

Spanier's volume on American foreign policy since World War II argues a case similar but by no means the same as that argued by Hans Morgenthau in *The Purpose of American Politics* [reviewed in *Science* **132**, 694 (10 March 1960)]. According to Spanier, *American Foreign Policy Since World War II* is (or should be) more preoccupied with power and national interest than with power as a means for achieving freedom in equality. Morgenthau laments our loss of direction, our forgotten historic purpose, and our failure of will to see that purpose through. Spanier wants us to transcend, if not to reject, our basic values in order the more effectively to sustain our national security and to protect our national interest. "Can the United States," he asks, "transcend its own values and experience, and do it quickly enough? This is the single most important question which confronts this country during the 1960's. Upon its answer will depend not just American and free-world security, but the non-Communist world's survival."

What, then, are the "values and experience" which America must "transcend" if it is to survive as a major power? Basically they are the "values and experience" of 19th-century liberalism. Liberalism, according to Spanier, in what will seem to many a caricature, identified the power of the state with the loss or limitation of individual freedom and therefore sought "to restrict this power." Power indeed was evil, and the Liberal was fond of quoting Lord Acton's aphorism that "power corrupts." By its attitude toward power, by "focusing upon the rights of the individual and minimizing the claims and authority of the state, liberal philosophy ignored the state's function to provide security."

As a corollary of its aversion to "power politics," Liberalism eschewed the use of force and violence. And this in turn was a logical corollary of the liberal faith in the essential goodness and rationality of man. Man in a state of nature lived at peace, hence any breach of the peace was unnatural, irrational, and inhuman. Classical liberal philosophy, says Spanier, regarded conflict as "a deviation from this norm (of peace), caused primarily by wicked statesmen whose morality and reason have been corrupted by the exercise of uncontrolled authority." From all this it follows that democratic (that is, liberal) states are peace-loving and undemocratic states are war-like. Hence the road to perpetual peace was to make the world democratic or at least "safe for democracy."

To transcend these allegedly liberal values the American people must be made to realize that "conflict is the natural offspring of clashing interests and groups, and that power plays a vital role in protecting, promoting, and compromising interests." We can no longer afford to regard power as evil, and we must learn to suppress the guilt feelings that arise in every liberal breast whenever, through circumstances beyond our control, we are compelled to take up arms. Not only must we abandon the rigid liberal dichotomy between peace and war but we must also abjure "the continued separation of force and diplomacy."

The argument is a familiar one that goes back to Hobbes and Machiavelli in Europe and at least to the liberal Jefferson, if not to Washington, in this country. Writing to Robert Livingston in 1803, Jefferson said "There is on the globe one single spot the possessor of which is our natural and habitual enemy. It is New Orleans, through which the produce of three-eights of our territory must pass to market. . . . France placing herself in that door assumes to us the attitude of defiance. . . . The day that France takes possession of New Orleans . . . we must marry ourselves to the British fleet and nation." Surely this is not the language of a man allergic to power and its uses in defense of the national interest. Nor indeed was Jefferson's comment during the War of 1812 when he observed: "it is for the general interest that (England) . . . should be a sensible and independent weight in the scale of nations." His long friendship for France did not blind him to the dangers of a Napoleonic hegemony in Europe. "Surely none of us," he said, "would wish to see Bonaparte conquer Russia and lay thus at his feet the whole continent of Europe. This done, England would be but a breakfast. . . ." Such a contingency, he continued, "I would as leave not have to encounter when I see how much trouble a handful of British soldiers in Canada has given us."

Isolation Vis-à-Vis Participation

The fact is that power politics have not been alien to the American liberal temper in either theory or practice. The Monroe Doctrine with Olney's gloss and Theodore Roosevelt's famous corollary, Manifest Destiny and the Mexican War, the Oregon question and "54-40 or Fight," Admiral Mahan's treatise on sea power, numerous cases of military intervention in Mexico and in other Caribbean states to protect our interests, and even our involvement in World Wars I and II were not sentimental journeys made by a middle-class liberal state blind to the uses of power and the interrelations of diplomacy and force. Even our policy of "splendid isolation" from Washington to Woodrow Wilson and FDR was not wholly a policy of withdrawal prompted by an aversion to power politics. During most of our history, while we have proclaimed a policy of isolation, we have practiced active participation, sometimes on a grand scale.

What troubles me as I read scholars of the so-called power politics school is to discover in operational terms what their counsel to "transcend . . . (our basic) values and experience" can mean. Aside from Spanier's apparent belief that we ought to be spending more on arms, he offers few specific suggestions upon which responsible decision makers could act. Even on the question of arms research and development he offers no evidence that the real source of our backwardness, if indeed we are backward in this area, is due to lack of funds. Administrative confusion, inter-

service rivalry, and Presidential ineptitude are not remedied simply by larger appropriations.

Although he is sharply critical of American foreign policy since World War II and calls for a radical transvaluation of our whole value system, Spanier's account of American performance on the new world stage is anything but a record of failure. To be sure, he repeats the usual *post hoc* arguments about our political innocence in pulling back from Eastern Europe, in leaving Germany divided and Berlin an island in a communist sea, and in demobilizing our vast army before a political settlement had been reached, as well as about the other "blunders" that a "realistic" diplomacy of force might have avoided. But all this is what FDR used to describe as an "iffy" argument. Could we in fact have done anything to "free" Eastern Europe, including Germany and Berlin, without continuing the war—this time against our quondam ally, the Soviet Union? Did the demobilization of our Army in fact create a power vacuum in Central Europe, and if it did, what difference did it make? The Russians, by and large, did not in fact advance significantly beyond the lines they held at war's end. Was not Russia so weakened by the destruction of her economy and the loss of manpower that, while she could hold what she had, she was in no position to do more?

Foreign Policy Record

I would not argue that American foreign policy since World War II has been an unblemished record of success. Nor would I defend the diplomacy of "Brinkmanship," "Massive Retaliation," or "Liberation" rather than "Containment." But the Japanese treaty, the Truman doctrine, the Marshall plan, and even the Korean War, to mention but a few items in the record, represent achievements of no mean proportions in defense of our national interest. To be sure, these and other policies have not been unmixed with liberal notions about "peace," "generosity," and "friendship," but neither are they the policies of a nation suffering from an excessive fear of power.

In addition to our failure to understand and to play the game of power politics, Spanier chides us for failure to understand "the anti-colonial revolutions of the underdeveloped nations." The real issue here, he says, is "whether the United States can supply the new nations with the capital funds and with a social message that can compete with the appeal of Communism." It would seem that our liberal tradition and our own revolutionary heritage should stand us in good stead as we confront the "revolution of rising expectations and national independence" that is sweeping through Asia, Africa, and the Middle East. But this, too, will call for a tough appraisal of the extent to which the democratic values and democratic institutions of a "People of Plenty" are exportable to "People of Poverty and Illiteracy," with little or no experience in either politics or administration. The wrong answer to this question may well be the Achilles heel of American foreign policy in the 1960's.

Spanier's analysis and his argument as to what must be done pose a challenge to every literate American. Must we abandon the liberal and humane values which have been our heritage to achieve security against communist infiltration, subversion, and conquest? Must we, in a word, lose our souls to save our skins? I think not.

PETER H. ODEGARD
Department of Political Science, University of California, Berkeley

Trends in the American Economy in the Nineteenth Century. A report of the National Bureau of Economic Research. Princeton University Press, Princeton, N.J., 1960. xi + 780 pp. $15.

This book fills a major need in the field of United States and Canadian economic history. The result of a joint effort by the National Bureau of Economic Research and the Economic History Association, the volume contains the most comprehensive and careful measurements yet made of the quantitative aspects of economic growth in Canada and the United States since 1790. Eighteen monographs, with critical commentaries, present new or improved statistical series covering the main trends in output growth, prices, income by sectors, factor payments, investment, and the balance of payments. These series tie in with contemporary series in national income, prices, wages, and so forth; hence, the volume makes possible reasonably accurate historical comparisons, in some cases for the first time.

THEODORE GEIGER
National Planning Association, Washington, D.C.

A Manual of Common Beetles of Eastern North America. Elizabeth S. Dillon and Lawrence S. Dillon. Row, Peterson, Evanston, Ill., 1961. 844 pp. Illus. $9.25.

This manual is the first of its kind on the largest group of animals, the Coleoptera. To be sure, there are manuals for general beetle collectors, but they are either too incomplete for reasonable accuracy or too bulky and technical for easy use. The Dillons' book strikes a happy medium. Keys identify some 1200 common beetles found in eastern North America. There are illustrations galore (544 of body parts) and 85 plates (four in color) of 1177 habitus drawings of species. If the user keeps in mind the fact that not all known species are included, he should find this book very useful, for never before has it been made so easy to identify beetles in the area concerned.

The introduction is a short discourse on the anatomy of beetles, collecting and preserving, and larvae. A chapter on ecology gives short accounts of the many environmental situations in which beetles are found; this chapter should suggest places for beginners to collect specimens. A key allows determination of 64 families and contains illustrations of body parts that might cause trouble for the user. The major part of the book, 85 percent, is concerned with each family and its species. Each family is briefly discussed; then keys to species are given. For convenience the many illustrations of difficult characteristics are placed very near the couplet concerned. Each species is described, and the habitus of each is illustrated on a plate. Finally, there is a glossary, a list of important technical articles, a list of faunal lists, and an index.

There is not much to criticize, but one serious fault is the use of many incorrect generic and specific names. These errors are unfortunate, and could easily have been avoided by consulting current catalogs or revisions. Some of the illustrations of body parts could be confusing: a line just inside the border indicates either a sulcus (Fig. 211) or convexity (Fig. 108). I have not made a search for errors, but one mistake in the key to families could cause some trouble: on page 39, couplet 18, Trogidae actually has closed mesocoxal cavities, whereas Scarabaeidae has open cavities (the figures referred to are correctly labeled).

It is my hope that this book will be shown to every undergraduate biology

student in our colleges and universities. Then perhaps interest in beetles would become commensurate with the numbers of species. I think this manual could arouse such interest. It would get the student over the first discouraging stumbling blocks: numbers of species, complexity of terms, and the great variation of form. Perhaps it is the wealth of illustrations that makes the volume a fine manual. And you can bet that a lot of experienced coleopterists will be flipping those 85 plates when trying to identify specimens in groups outside their specialty. *Caveant* Coleoptera!

T. J. SPILMAN
U.S. Department of Agriculture, Washington, D.C.

Holzanatomie der Europäischen Laubhölzer und Sträucher. Pal Gregus. Akademiai Kiado, Budapest, Hungary, 1959. 330 pp. + plates. Illus.

This large and thorough volume constitutes a major contribution to the literature on the identification of wood and woody species on the basis of xylotomy. It is a presentation of photomicrographs, diagnostic pen and ink sketches, detailed xylotomical descriptions, summary tables of characteristics, and keys to the identification of European deciduous trees and shrubs based on the structure of their wood. As such, it is a revised and enlarged edition of the author's successful *Bestimmung der mitteleuropäischen Laubhölzer und Sträucher auf xylotomischer Grundlage* which is now out of print.

The book is divided into a general section which treats the preparation of material and the fundamentals of the xylotomical determination of woody species, and a detailed section which treats 154 genera of 61 families of the Monochlamydeae, Dialipetalae, and Sympetalae. The detailed section is divided into an expanded key to species and a thorough description of the anatomical features of the wood of each species treated. It is followed by 307 plates (9 by 13 inches) of photomicrographs and drawings of the 303 species treated. Six summary (*Merkmalübersicht*) tables are included inside the back cover of the volume.

The diagnostic key is presented in both German and English and uses both qualitative and quantitative characteristics. It is elaborated to include minor variations within species and specimens; I found it to be quite workable.

The descriptions of the xylotomical features of the wood of each species are presented in German, but they can be readily translated by anyone who has a command of the basic German vocabulary of wood anatomy. The features of cross, radial, and tangential sections are presented in great detail.

The plates are large and exceptionally well done. Each plate shows four photomicrographs (2 by 3 inches) and a series of pen and ink sketches of diagnostic features. The photomicrographs include a cross section (× 30), a cross and a tangential section (× 100), and a radial section (× 200). Where applicable, pen and ink sketches are given of vessels, tracheid shaped vessels, tracheids, wood fibers, fiber tracheids, wood parenchyma cells, ray cells, supplementary fibers, and septate fibers.

This volume, along with its companion, the author's *Identification of Living Gymnosperms on the Basis of Xylotomy*, will provide data and fill a need in the several areas of plant science concerned with wood and woody plants. It provides a comprehensive view of the structure of woody plants, for general botanical purposes. It serves as an exhaustive source of data for advanced study of wood anatomy and its relationship to phylogeny. Finally, it provides a comprehensive reference manual for workers in the fields of plant anatomy, wood technology, forestry, paleobotany, and related areas.

ELWOOD B. EHRLE
Department of Science, State University College of Education, Geneseo, New York

Staining Methods. Histologic and histochemical. J. F. A. McManus and Robert W. Mowry. Harper (Hoeber), New York, 1960. viii + 423 pp. Illus. $10.

At a time when the value of the information that can be derived from studying cells and tissues has been generally recognized by many disciplines, a book "integrating the newer methods of tissue and cell examination into histologic techniques" is highly welcome. The authors present here a selection of the methods they consider to be most valuable for the proper staining of histologic preparations. The selection, based on the authors' personal experience with the different techniques, includes well-established earlier procedures as well as newer methods—for instance, staining techniques used in electron microscopic studies which have recently been improved by Strugger, who applied additional "staining" with uranium salts for the detection of microstructures in cell constituents.

A discussion of the different methods of preparing the tissue for staining precedes the chapters on specific methods for study of the constituents of cells and tissues and for the study of special cells, tissues, and organs. Two appendixes—one giving an outline of basic techniques and another giving dilution and solubility tables, molar values, and buffers—increase the monograph's value for routine work and research.

The book continues the tradition of the famous standard works by Mallory, Bertrand, Lillie, and Glick, to mention just a few of the earlier and the more recent authors, and it will definitely fill the need of a modern tissue laboratory.

A. T. KREBS
Department of Biology, University of Louisville

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Large-Scale Ground-Water Development. Water Resources Development Centre. United Nations, New York, 1960. 84 pp. Paper, $1.25. The first of a series of studies to be undertaken by various UN organizations. Contents cover basic considerations relating to use, stages of development, economic and financial aspects, the role of governments, and rights and other legislative matters.

Research in Wisconsin. A technical digest of research results in fish management, forestry, and game management, 1959. Ruth L. Hine, Ed. Wisconsin Conservation Dept., Madison 1, 1960. 104 pp.

Scientific and Technical Personnel in American Industry. Report on a 1959 survey. Prepared by the U.S. Department of Labor. National Science Foundation, Washington, D.C., 1960 (order from the Supt. of Documents, GPO, Washington 25). 66 pp. $0.45. American industry employed approximately 800,000 scientists and engineers in January 1959. Engineers were found to number 615,000 (80 percent of the survey); the 149,000 scientists included 72,000 chemists, 18,000 life scientists, 15,000 physicists, 15,000 earth scientists, and a smaller number in other occupational groups.

Soviet Education Programs. Foundations, curriculums, and teacher preparation. Bulletin 1960, No. 17. William K. Medlin, Clarence B. Lindquist, and Marshall L. Schmitt. U.S. Office of Education, Washington, D.C., 1960 (order from Supt. of Documents, GPO, Washington 25). 299 pp. $1.25.

Reports

Auditory Information from Subcortical Electrical Stimulation in Cats

Abstract. Animals trained to respond to sound stimuli were found to perform the learned response when they were electrically stimulated through electrodes chronically implanted in subcortical structures of the auditory pathway. Other animals trained to respond to electrical stimulation of subcortical auditory structures showed differential transfer effects depending on the positions of the stimulating electrodes.

It has long been known that auditory sensations may be produced in human subjects by direct electrical stimulation in or near auditory areas of the cerebral cortex (*1*). The sensory effects produced—buzzing, knocking, booming, and so on—have been crude, perhaps because of the difficulty of entering a functional system at the level of its greatest organizational complexity. Some evidence has also come from conditioning studies on animals, in which direct electrical stimulation of areas of the cerebral cortex has been successfully used as the conditioned stimulus (*2*). Surprisingly enough, no attempt has been made up to the present (*3*) to inject behaviorally meaningful information into lower, presumably less complex, levels of the auditory system where there might be more promise of controlling the qualities of the sensations produced.

As a first step in the investigation of this problem, ten cats were prepared with bipolar electrodes chronically implanted at different levels of the central auditory pathway. The animals were divided into two groups. Group 1 consisted of four animals which were trained to avoid mild shock to the foot by flexing the left hind leg when presented with an auditory warning signal. After training, these animals were tested to see whether the conditioned response could be elicited by direct stimulation of the inferior colliculus or the cochlear nucleus. Group 2 was made up of six animals which were conditioned to respond to direct stimulation at different subcortical levels of the auditory or visual pathways. The electrodes were placed in the region of the inferior colliculus in three animals, in the medial geniculate body of one, in the auditory radiations in one, and in the optic tract in one. The first three animals were trained to make a leg flexion response; the other three were trained to avoid shock by crossing from one compartment to the other of a double-grill box when given a warning burst of direct stimulation. After initial training, the animals of group 2 were tested for transfer of the learned habit to stimulation of leads other than those used in conditioning and to presentation of different sounds over a loudspeaker. Electrode positions were confirmed electrophysiologically and anatomically.

All conditioning and test procedures were carried out with the experimental animal isolated in a sound-treated room. Electrical stimuli were delivered from a Grass S-IV stimulator and consisted of trains of monophasic or biphasic square waves. Stimulation current flow to the animal was monitored oscillographically.

During tests of transfer of the learned responses to novel stimuli, animals were never punished for failure to respond to the new stimuli.

The results obtained with group 1 were unequivocal. After being trained to respond to sound stimuli, all animals of this group immediately gave the conditioned response when electrically stimulated in the region of the inferior colliculus. The ratios of correct responses to numbers of test trials for these animals were 42/56, 33/53, 12/34, and 7/12. In contrast to these results, stimulation of the cochlear nucleus was much less effective: two of the animals never responded at all to such stimulation and the other two showed signs of early extinction of the response. At all but the lowest stimulation currents given at the cochlear nucleus, unconditioned motor responses were elicited, perhaps through inadvertent stimulation of vestibular fibers. These unconditioned responses seemed to interfere with expression of the conditioned response.

All animals of group 2 were successfully trained to respond to direct stimulation of selected electrodes positioned in subcortical levels of either the auditory or visual system. However, transfer results for these animals showed important differences. Of the three animals trained with inferior colliculus stimulation, only one responded significantly to test sound stimuli, giving 15 conditioned responses (CR's) to 25 test trials. The electrodes used for stimulating this animal during conditioning were located dorsolaterally in the colliculus and were across brachium fibers; there was no transfer of the response when stimulation was applied through electrodes centrally placed in the main nucleus of the inferior colliculus or in the tegmentum. All electrodes of the other two animals trained with colliculus stimulation were in the main body of the nucleus, and stimulation through any electrode was effective in eliciting the learned response.

The animal trained to respond to stimulation of the auditory radiations showed transfer of the response to stimulation of auditory cortex (5 CR's in six trials) and to stimulation with single acoustic clicks (8 CR's in 11 trials) but did not respond to acoustic stimuli with tonal quality (0 CR's in five trials).

One animal of group 2, after training with medial geniculate stimulation, showed a very low response level to both sound stimulation (1 CR in nine trials) and lateral geniculate stimulation (1 CR in nine trials).

The final animal of group 2, after being trained to respond to direct stimulation of the optic tract, did not show transfer of the response to direct stimulation of the medial geniculate body (0 CR's in eight trials). It also failed to respond to sound stimuli (0 CR's in three trials).

Bilateral ablation of auditory areas of the cortex produced a severe postoperative deficit in three of the four animals tested; two were trained to direct stimulation and one to sound.

The evidence presented here strongly supports the conclusion that auditory sensations may be produced by direct electrical stimulation at subcortical levels of the central acoustic pathway. The results suggest that greater control of the quality of the sensations pro-

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

duced may be obtained by subcortical than by cortical stimulation. Especially suggestive are the data showing behavioral differentiation of stimulation sites in mesencephalic auditory system structures, particularly as there is some electrophysiological evidence for tonotopic organization within the inferior colliculus (*4*). It is hoped that the combined behavioral and stimulation techniques of this preliminary study will prove to be powerful tools for the investigation of theories of the central code of the auditory system (*5*) and perhaps of the visual system as well (*6*, *7*).

PHILIP C. NIEDER*
WILLIAM D. NEFF
Laboratory of Physiological Psychology, University of Chicago, Chicago, Illinois

References and Notes

1. See W. Penfield and T. Rasmussen [*The Cerebral Cortex of Man* (Macmillan, New York, 1950)] for presentation of data on sensory effects from cortical stimulation in a long series of human subjects.
2. R. B. Loucks [*J. Comp. Psychol.* **25**, 315 (1938)] reported conditioning leg flexion or salivation in dogs with direct stimulation of "visual" cortex as the conditioned stimulus; R. W. Doty and L. T. Rutledge [*J. Neurophysiol.* **22**, 428 (1959)] found that cats trained in leg flexion with cortical direct stimulation as the cue were more easily trained to respond to photic or sound stimuli than naive animals, and vice versa; R. W. Doty and C. Giurgea [*The Physiologist* **1**, 17 (1958)] conditioned leg flexion in dogs by using direct stimulation of cortical points as the conditioned and unconditioned stimuli.
3. A preliminary report of this work was presented by W. D. Neff, P. C. Nieder, and R. E. Oesterreich [*Federation Proc.* **18**, 112 (1959)].
4. W. R. Thurlow, N. B. Gross, E. H. Kemp, K. Lowy, *J. Neurophysiol.* **14**, 289 (1951).
5. For a presentation of theoretical work on this subject see J. C. R. Licklider [in *Information Theory*, C. Cherry, Ed. (Butterworth, London, 1956)].
6. A suggestion for central coding of visual pattern information has been outlined by P. Nieder [*Science* **131**, 934 (1960)].
7. This research was supported in whole or in part by the U.S. Air Force under contracts No. AF 49(638)-925 and No. AF 19(604)-5526 monitored by the Air Force Office of Scientific Research and the Operational Applications Office of the Air Force Command and Control Development Division.
* Postdoctoral fellow, National Institute of Mental Health, U.S. Public Health Service.

7 December 1960

Water and Myotonia in Goats

Our work on myotonia, in goats, was frustrated by the great variation in the gravity of the symptoms in one and the same animal. Our efforts to correlate these variations with meteorological changes, food, exercise, or other factors failed. Lately, we have found indication that the gravity of the symptoms depended on the water intake. To test this point, three myotonic goats were kept on mixed dry food, only very limited grazing being allowed. Water was withheld for periods of 3 to 7 days, these periods being followed by similar periods in which water was offered ad libitum. We found that on withholding water, the myotonic symptoms disappeared altogether within 3 days to return with full gravity within 2 to 3 days when water was given. These results are illustrated in Fig. 1. The abscissa shows days and the ordinate, the gravity of symptoms on an arbitrary scale (the intensity of stiffness was marked by one to five crosses, and the number of crosses was multiplied by the duration of stiffness in seconds). Upward arrows mean withholding water, downward arrows mean giving water (*1*).

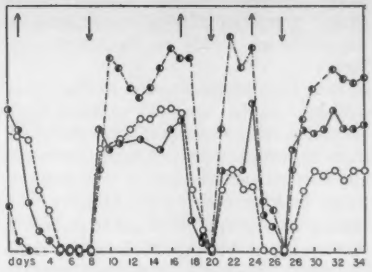

Fig. 1. Effect of water on myotonic symptoms in goats.

ANDREW HEGYELI
ALBERT SZENT-GYÖRGYI
Institute for Muscle Research at the Marine Biological Laboratory, Woods Hole, Massachusetts

Note

1. This research was sponsored by grants from the Muscular Dystrophy Associations of America and the Commonwealth Fund.

6 December 1960

Odontoblasts: Vacuoles and Inclusions

Abstract. Lipid granules have been found in the cytoplasm of odontoblasts and in the odontoblastic extensions within the dentinal tubules. It is suggested that these granules represent specific activity on the part of the normal cell as well as an increase in number after injury. While they are not limited to occurrence within the vacuoles in the cytoplasm of the odontoblasts, the relationship of the granules to the vacuoles suggests that the vacuoles are also a part of the physiologic activity of the adult odontoblasts.

This report is a preliminary account of the observation of lipid inclusions in the cell body of odontoblasts and in the cytoplasmic extension of the odontoblasts into the dentinal tubules. The granules were first observed during attempts to determine the contents of vacuoles which previously had been reported as occurring in odontoblasts. While other investigators have considered the vacuoles to be indicative of degenerative change (*1*) or inadequate fixation (*2*), or have mentioned them without attaching apparent significance to them (*3*), I have assumed them to be of physiologic significance.

Clinically healthy human teeth, both deciduous and permanent, were sectioned longitudinally within minutes after extraction. They were fixed in either neutral formalin or osmium tetraoxide as Flemming's strong fluid. Decalcification was achieved by using 0.5*M* sodium triethylenediamine tetraacetate buffered to *p*H 8.5 at 60°C. The specimens were embedded in paraffin after dehydration by graded ethyl alcohol or were washed and embedded immediately in polyethylene glycol. Paraffin sections were cut at 5 μ while the water wax sections were cut at 3 μ for observation by phase-contrast microscopy. Sections from each specimen were stained with hematoxylin and eosin, silver stains (*4*) and Sudan B. The material for phase microscopy was unstained. In addition to the sectioned material, fresh suspensions of odontoblasts scraped from the pulp chamber were studied and utilized as heat-fixed smears and as smears made from pulps prepared in the manner described above.

Vacuolization of the odontoblasts in the coronal portion of the pulps was found in each specimen; approximately every third to fifth cell was affected. The vacuoles varied from several microns in diameter to a proportion which appeared to engulf the nucleus. Cells in all levels of the palisade of odontoblasts were vacuolated. The shrinkage which was evident in the paraffin-embedded material distorted the vacuoles and produced spaces between the cell bodies of the odontoblasts. The vacuoles were observed in approximately the same frequency in fresh smears, heat-fixed smears, and smears made from fixed material.

Spherical bodies 1 to 2 μ in diameter were found in the cytoplasm of the odontoblasts fixed with osmic acid and in the formalin-fixed material, if this latter tissue was sectioned in water wax or smeared and if washing was minimized. In the material fixed with osmic acid, the granules could be preserved through alcohol dehydration and paraffin embedding and then could be demonstrated as silver-positive bodies. Bulk staining of the formalin-fixed material with Sudan B, with subsequent preparation of smears, also revealed the black to dark-green granules. Phase-contrast microscopy of fresh material, wet smears fixed with formalin or osmic acid, or water wax sectioned material

mounted in water consistently demonstrated the granules, although they were less numerous in the formalin-fixed material.

The granules appear to form in the cytoplasm among the mitochondria in the "Golgi zone" and then to be engulfed by the forming vacuoles in many instances or to pass peripherally into the odontoblastic process within the dentinal tubule. When the granules are seen in the vacuoles, they exhibit Brownian movement which is apparently limited by filamentous partitions within the vacuoles. The granules also appear to be 'discharged' into the predentin among the Korff's fibers when the odontoblast disintegrates as a part of its cycle. In addition, the granules appear in greater numbers in the odontoblastic processes subadjacent to areas of experimental injury to the tooth surface.

Inasmuch as the fixation of the odontoblasts can be assumed to have been complete within minutes after the teeth were removed from the mouth, the occurrence of vacuoles in the cytoplasm of these cells can be considered to be indicative of physiologic activity. This is further supported by the appearance of the vacuoles in the heat-fixed smears and in the fresh material.

The origin of the granules may be explained on the basis of degeneration or specific secretory activity of the mitochrondria (*5*). An unknown spherical body was described by Nylen and Scott as occurring in the Golgi zone in young odontoblasts (*6*). The granules described in the present report may well represent similar bodies in the more mature odontoblasts.

It would appear that the vacuoles and granules described in this report represent specific physiologic activity in odontoblasts and that the migration of the granules into the peripheral dentin through the odontoblastic processes is a function of the maturation of dentin. Also, since the granules are increased in number in the injured cells, they may represent a specific response to stimulation by injury. It may further be concluded that the granules are basically lipid in character because of the solubility factors and the response to osmification (*7*).

J. M. STEWART
Ruth M. Stewart Memorial Research Laboratory, Good Samaritan Hospital, West Palm Beach, Florida

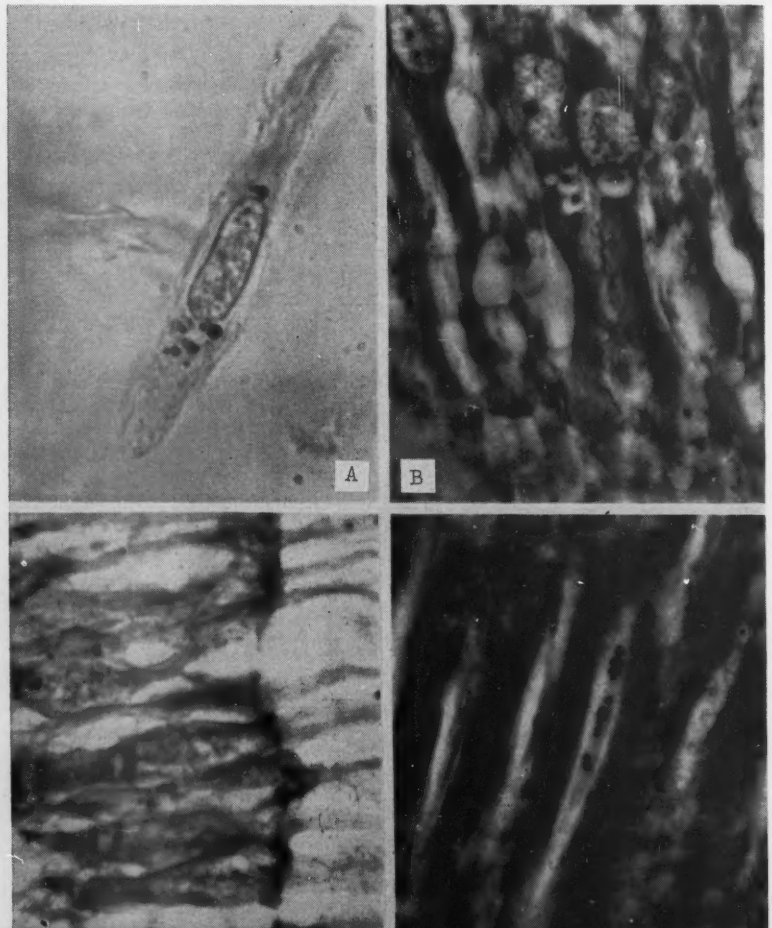

Fig. 1. Human odontoblasts, original × 2200, osmic acid fixation. (*A*) Unstained odontoblast in wet preparation showing granules at each end of nucleus. (*B*) Paraffin section with silver stain showing many granules in the cytoplasm and inside the vacuoles. (*C*) Carbowax section viewed with phase contrast showing vacuoles and phase-positive granules. (*D*) Section of mature dentin showing granules inside the cytoplasmic extension of the odontoblasts within the dentinal tubule.

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7. This study was aided in part by a grant (D928) from the U.S. Public Health Service.

9 November 1960

Quantitative Analysis of Evolution of the Brain in Mammals

Abstract. Empirical equations derived from brain size (E) and body size (P) of archaic-Eocene, Oligocene, and Recent mammals were all of the form, $E = kP^{2/3}$; $k = 0.03$ for the Eocene, 0.06 for the Oligocene, and 0.12 for the Recent groups. It is suggested that k, which has been used as an index of cephalization in contemporary mammals, may be an appropriate measure of brain evolution in the mammals as a class.

The purpose of this report is to determine general expressions for brain development in mammals at various stages of their evolution. At the turn of the century, Dubois (*1*) proposed a quantitative measure of cephalization in contemporary mammals based on an equation relating brain weight, E, to body weight, P:

$$E = k P^{\beta} \qquad (1)$$

where k and β are constants; Dubois' index of cephalization was E/P^{β} or k. Despite criticisms of this index (*2*) it

remains "the only neurological character for which a correlation with behavioral capacity in different animals is supported by significant evidence" (*3*).

In an earlier paper (*4*) I assumed Eq. 1 with $\beta = 2/3$ to hold for archaic as well as for Recent mammals. I also suggested that the primitive value for k could be determined by using the contemporary opossum to represent the primitive condition, because this animal is similar to didelphids from early periods in the adaptive radiation of mammals. The research reported now (*5*) presents direct tests of these hypotheses, using endocranial volumes and body volumes for fossil mammals at early and intermediate evolutionary stages.

Although I was able to measure the endocranial volumes of about 50 specimens, I could find illustrations of mounted skeletons of only 16 of these, eight Oligocene and eight Eocene or earlier, from which to estimate body volumes. The Oligocene sample is from the White River area of South Dakota and Nebraska. It is a relatively homogeneous group representing the fauna of that area over the short time, geologically speaking, of about 5 million years, and dates back about 30 million years. The more diverse "Eocene" sample (which includes one Paleocene form) covers a 20-million-year period, from about 60 to 40 million years ago, and is based on specimens from various European and North American fossil deposits.

Body volumes for extinct mammals were determined either from accurate scale models of restorations based on mounted skeletons, from other published estimates (*6*), or, in those cases where dimensions were very similar to contemporary forms, from body-weight data on the contemporary forms. Volume and weight were assumed equal. The error introduced by this assumption will not exceed 10 percent of the absolute weight, and because the logarithms of the weights or volumes were used, the error was no more than 2 percent for the smallest specimen and less than 1 percent for the largest.

Data on the opossum, *Didelphis marsupialis*, which are particularly important for this analysis, had to be revised from those used earlier (*7*). The earlier data, taken from von Bonin (see *4*), were $E = 6.3$ g and $P = 1700$ g, but a road-kill from the Ohio Fish and Wildlife Service with linear dimensions in the middle of the range given by Hall and Kelson (*8*) weighed about 4500 g. I therefore sought larger published weights and found these in Weber (*9*): $E = 6.5$ g and $P = 3480$ g. With $\beta = 2/3$ these result in $k = 0.028$. By using the opossum as our type, the hypothetical relationship for primitive mammals, that is, mammals at an early stage in their adaptive radiation, could now be written:

$$E = 0.028\, P^{2/3} \qquad (2)$$

For comparative purposes the brain and body weight relationship in Recent mammals was reanalyzed by selecting a sample from published data on specimens similar in adaptive niche and body configuration to the fossil sample. Only specimens within the range of body sizes reported in standard works on mammalogy (for example, *8*) were included.

The results are presented in Fig. 1. It should be noted, first, that the logarithmic form of Eq. 1 is:

$$\log E = \log k + \beta \log P \qquad (1a)$$

If Eq. 1 accounts for the data, the points in Fig. 1, which uses logarithmic scales for the coordinates, will be distributed about straight lines with slopes, β, and intercepts, k. (The intercept will be the value of E at $P = 0.001$ kg.) If β is a mammalian constant equal to 2/3, the slopes should all be about 2/3, and if Eq. 2 is correct the lowest k should be 0.028.

The lines drawn on Fig. 1 are least-squares fits (*10*) of Eq. 1a for each evolutionary stage. The empirical equation for the Recent sample, excluding the opossum, is:

$$E = 0.115\, P^{0.664} \qquad (3)$$

For the Oligocene sample, the numbered points in circles, it is:

$$E = 0.055\, P^{0.655} \qquad (4)$$

The Eocene sample, the numbered points in squares, can be divided into two groups on evolutionary grounds. Points 1, 4, 5, and 6 in Fig. 1, which are near the Oligocene line, are for a primate and three perissodactyls from the Bridger basin middle Eocene, orders that were to continue their adaptive radiation into later geological periods. The other points, 2, 3, 7, and 8, in Fig. 1 are for a creodont from the upper Paleocene, a condylarth and a pantodont from the lower Eocene, and a uintathere from the middle Eocene. These latter specimens are from groups that had achieved their maximum radiation

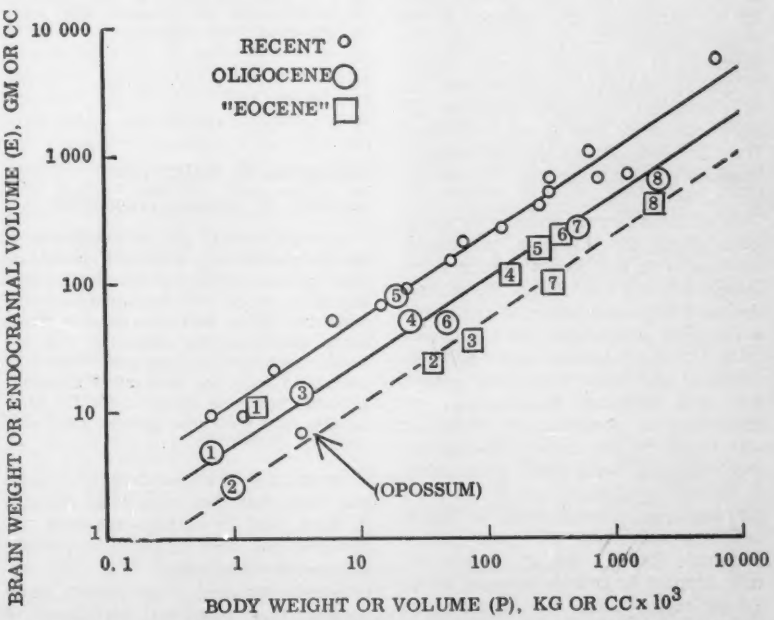

Fig. 1. Relation between brain and body measures for mammals at three evolutionary levels. Lines are least-squares fits to Eq. 1a; upper line, Recent; middle line, Oligocene; lower dashed line, archaic "Eocene" and opossum. Fossils numbered in the graph and museum catalogue numbers (see *5* for museum initials) of the endocranial casts used are: Oligocene: 1, *Ischyromys typ.* USNM 15934; 2, *Palaeolagus haydeni* AMNH 5674; 3, *Pseudocynodictis* AMNH 9766; 4, *Hoplophoneus primaevus* CNHM-UM 2 and USNM-22538; 5, *Mesohippus bairdi* AMNH 3940 and USNM-22539; 6, *Merycoidodon culbertsoni* CNHM-UC 256; 7, *Subhyracodon* USNM-22540; 8, *Menodus giganteus* AMNH 15599. Eocene: 1, *Smilodectes gracilis* USNM 17997; 2, *Arctocyon primaevus* AMNH 10431; 3, *Phenacodus primaevus* AMNH 4369; 4, *Hyrachyus modestus* AMNH 11651; 5, *Mesatirhinus petersoni* AMNH-P39558 (Princeton-10041a); 6, *Palaeosyops leidyi* AMNH 1544; 7, *Coryphodon hamatus* AMNH 15598; 8, *Unitatherium mirabile* USNM-11770 (AMNH-1036).

by early or middle Eocene times and were approaching extinction. They can, therefore, be considered to be better representatives of archaic mammals at an early stage of evolution than the entire Eocene group. The dashed line in Fig. 1 is a least-squares fit to the "Eocene" points, 2, 3, 7, and 8, and the contemporary opossum, which was assumed to be representative of forms of that type. The equation of the dashed line is:

$$E = 0.026\,P^{0.607} \qquad (5)$$

It should be emphasized that the only restriction imposed by this analysis was that the lines in Fig. 1 be straight. They have slopes that are essentially 2/3 and are displaced as they are in the vertical dimension because these slopes and displacements fit the data best.

Despite the small number of points, the equations are relatively well determined. The exponents of Eqs. 3, 4, and 5, that is, the slopes of the lines in Fig. 1, stated with their standard errors, are: for the Recent sample, $\beta = 0.664 \pm 0.012$; for the Oligocene sample, $\beta = 0.655 \pm 0.020$; and for the archaic "Eocene" and the opossum, $\beta = 0.657 \pm 0.028$. The linear regression accounts for 97 percent of the variance of the Recent sample, 94 percent of the Oligocene, and 99 percent of the archaic "Eocene" and the opossum. We can conclude that for these specimens the likelihood of a true β much different from 2/3 is small, and that the linearity implied by assuming Eq. 1a is supported by the data.

In addition to confirming my speculations about the primitive relationship between brain and body weight in mammals (compare Eqs. 2 and 5), perhaps the most important aspect of the results is that they give simple, yet mathematically precise, statements about the evolution of the brain. The same general rule that describes brain-to-body relationships in contemporary mammals was found in the earlier evolutionary stages sampled here, and the parameter, k, differentiated those stages. This parameter is not as successful in differentiating subgroups of contemporary mammals (see 7), but the present results support its consideration as an index of cephalization for the mammals as a class at different stages in evolution.

HARRY J. JERISON
Antioch College, Yellow Springs, Ohio

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5. Most of this research was performed under grant M-3145(a) from the National Institutes of Health and was supported in part by the U.S. Air Force under contract No. AF 49(638)-536 monitored by the Air Force Office of Scientific Research of the Air Research and Development Command. The results were included in a paper presented to the Psychonomic Society, 2 September 1960. Fossil specimens used in this work are from the departments of vertebrate paleontology at the American Museum of Natural History (AMNH), Harvard's Museum of Comparative Zoology (MCZ), the U.S. National Museum (USNM), and the Chicago Natural History Museum (CNHM). I wish to thank E. H. Colbert, G. G. Simpson, A. S. Romer, C. L. Gazin, and W. D. Turnbull of those museums for allowing me access to these materials. Special thanks are due Dr. Gazin for identifying *Subhyracodon* and *Hoplophoneus* at the U.S. National Museum on the basis of associated teeth, and for copies of endocranial casts of *Subhyracodon* and *Uintatherium*. My visit to Harvard's Museum of Comparative Zoology was made especially memorable by the gracious hospitality of Dr. Tilly Edinger. Her monograph *Evolution of the Horse Brain* [*Geol. Soc. Am., Mem.* **25** (1948)] suggests important departures from the general evolutionary trend described here and includes an invaluable bibliography.
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21 November 1960

Alterations in Sialic Acid Content of Human Transferrin

Abstract. Starch gel electrophoresis of human transferrin treated with neuraminidase revealed a pattern of five bands whose intensities varied with neuraminidase concentration. Sialic acid analysis after starch block electrophoresis suggested that the bands represented the stepwise removal of sialic acid from the transferrin molecule. Evidence was also obtained for the purification of a particular genetic transferrin variant.

Genetically determined polymorphism has been described in several proteins in man, and in certain instances the variation has been localized to a single aminoacid substitution (*1*). The experiments reported in the present study suggest that observed variations in electrophoretic mobility may also represent differences in carbohydrate content.

Poulik (*2*) has described alterations in the electrophoretic mobility of serum protein components after treatment with diphtheria toxin. Using the technique of immunoelectrophoresis, Schultze and Schwick (*3*) have shown a decrease in mobility of the "β_1-iron-combining globulin" upon incubation with neuraminidase, an enzyme which cleaves the glycosidic bond joining sialic acid to a protein molecule. After the introduction of starch gel electrophoresis by Smithies (*4*), several genetically controlled variations in human serum β-globulins were described and subsequently identified as transferrin, the iron-binding component of serum. Neuraminidase-treated transferrin has recently been reported to separate into two sub-units in the starch gel (*5*).

In the present experiments transferrin was detected by its characteristic position in vertical starch gel electrophoresis in borate buffer, and its iron-binding property was confirmed by autoradiography (*6*). Transferrin C was prepared from the beta fraction of 20 ml of normal serum isolated by starch block electrophoresis in *p*H 8.6 barbital buffer (*7*). The beta fraction was chromatographed on TEAE cellulose and eluted with 0.025*M* Na_2HPO_4. The purified transferrin migrated as a single component in starch gel electrophoresis. Transferrin concentration was determined by the Folin-Ciocalteau procedure, and a standard curve was calculated from a transferrin sample dried to constant weight. Neuraminidase experiments on normal human serum and on the purified transferrin preparations were carried out by incubating samples at 37°C at various enzyme concentrations for 12 hours. The neuraminidase preparation was a ten times concentrated filtrate of *Vibrio cholerae*. The unconcentrated filtrate inhibited the agglutination of chicken erythrocytes at a 1:128 dilution when titrated against the Lee strain of influenza B virus (*8*). Sialic acid was determined by a modification of Bial's orcinol reaction (*9*), and optical density was measured in a Beckman Model DU spectrophotometer at 570 and 670 mμ, as suggested by Svennerholm (*10*). A standard curve was calculated from sialic acid purified from human ovarian cyst fluid.

Treatment of normal transferrin with neuraminidase split the single transferrin C (Fig. 1, band 4) into four additional slower-moving, iron-binding components (bands 3 to 0) whose relative intensities depended upon concentration of neuraminidase. A similar pattern was obtained by varying incubation time. No further bands appeared with an additional tenfold increase in neuraminidase concentration.

Starch block electrophoresis of purified transferrin treated with neuraminidase (Fig. 2) showed that the protein peak of the treated material migrated slower than an untreated control. Ultracentrifugal analysis could detect no difference in *S*-rate between the treated and untreated material. Sialic acid analysis revealed that the treated material contained approximately one to two sialic acid residues per molecule of

transferrin, with the fewest residues located in the slowest-moving portion of the peak, whereas the sialic acid content of the untreated control remained constant at approximately four residues per molecule throughout the peak, in agreement with previously reported values (*11*).

A comparison of the results obtained by starch gel and starch block electrophoresis suggested that the stepwise changes in mobility (Fig. 1) reflected variations in the number of sialic acid residues. Each of the four sialic acid residues of the transferrin molecule was readily accessible to the enzyme, and each residue contributed a definite increment to the electrophoretic mobility of the intact protein. As the glycosidic bonds were hydrolysed by the enzyme, an increasing but random removal of sialic acid took place until the four residues had been removed, after which there was no further change in mobility. Band 4 represented the untreated transferrin and band 0 appeared to represent the complete removal of sialic acid from the molecule, while bands 1 to 4 contained one to four sialic acid residues, respectively. With increased amounts of enzyme, most of the transferrin appeared in band 0, with only a small quantity in band 1.

In certain sera examined by autoradiography, normal transferrin C was accompanied by a faint slower-moving component in the position of band 3. This previously reported "shadow" band (*12*) may represent either a naturally occurring heterogeneity in transferrin C or the loss of a sialic acid residue from transferrin as a result of aging or contamination. A splitting of transferrin similar to the stepwise pattern obtained with neuraminidase has been observed in the starch gel upon treatment of transferrin with diphtheria toxin (*13*).

Neuraminidase treatment of haptoglobin and ceruloplasmin in serum resulted in a gradual decrease in mobility instead of the stepwise pattern obtained for transferrin. Since the ceruloplasmin molecule contains 10 sialic acid residues and the haptoglobin molecule at least 15 (*14*), it was unlikely that small differences in sialic acid content would yield a stepwise pattern in the gel. However, the decrease in mobility was accompanied by a spreading of the protein band which suggested that the leading portion of the band contained two or three more sialic acid residues per molecule than the trailing portion.

Because of the somewhat similar electrophoretic patterns obtained for abnormal transferrin variants and neuraminidase-treated normal transferrin (Fig. 1), it was of interest to determine the sialic acid content of an available

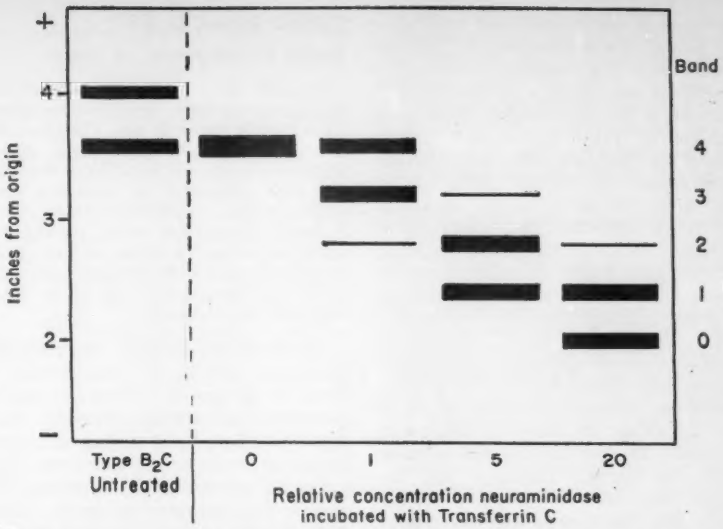

Fig. 1. Diagram of autoradiograph after starch gel electrophoresis of serum transferrin type C incubated with various concentrations of neuraminidase and of untreated type B_2C.

variant. Since individuals homozygous for an abnormal transferrin are extremely rare, a procedure was developed for the separation of an abnormal type from the serum of a heterozygote. The genetic transferrin variant B_2 was isolated by chromatography of the beta fraction from serum of transferrin type B_2C. Transferrin C appeared at the column volume in 0.025*M* Na_2HPO_4 whereas the B_2 component was slightly retarded. The purified B_2 and C components migrated as single bands in starch gel electrophoresis and as single peaks in the ultracentrifuge with no detectable difference in *S*-rate.

A single precipitin arc was obtained with each component by immunoelectrophoresis against antihuman serum although the precipitin line was displaced toward the anode for type B_2. Immunological studies in Ouchterlony plates confirmed that both transferrin B_2 and neuraminidase-treated type C were antigenically indistinguishable from normal transferrin C. When tested for purity against antihuman serum by the double diffusion method of Preer (*15*), transferrin C showed a single band, whereas 15 bands were observed with the original beta fraction. The B_2 preparation, however, revealed a trace

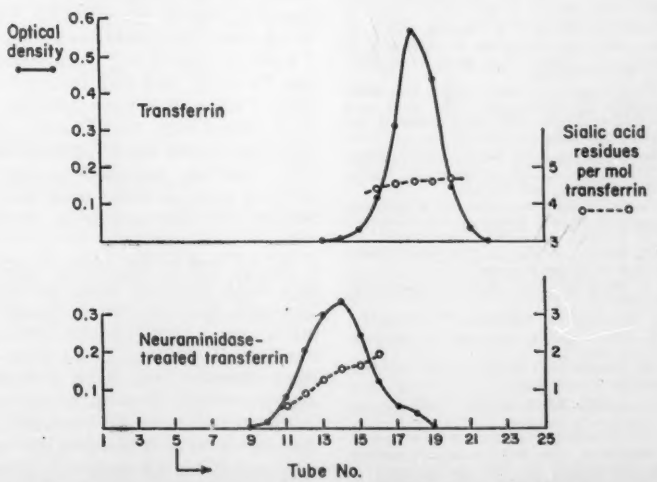

Fig. 2. Protein and sialic acid analysis after starch block electrophoresis of purified untreated transferrin C (top) and neuraminidase-treated transferrin (bottom). Starch gel electrophoresis of the untreated transferrin showed a single band in the 4 position. The treated material showed bands in the 2, 1, and 0 positions.

component which appeared only after 48 hours. It was estimated by dilution studies that this component could represent no more than a maximum of 5 percent of the total protein. Sialic acid analyses on transferrins B_2 and C could detect no significant difference. Further experiments are being conducted to determine the nature of the structural difference between these two components. Although differences in sialic acid content would be sufficient to account for observed variations in electrophoretic mobility of certain transferrins, the variation would be expected to extend to a specific genetically determined amino acid difference in the protein backbone. Although no definite selective advantage is known which could maintain the transferrin polymorphism (*16*), the genetic variation may influence resistance to infectious disease (*17*). The variation in charged groups may also affect the dissociation of the iron-transferrin complex according to the equilibrium postulated by Laurell (*18*) and alter the transfer of iron to sites of storage or synthesis (*19*).

W. CAREY PARKER
ALEXANDER G. BEARN

Rockefeller Institute,
New York, New York

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21 November 1960

Critical Period in the Social Development of Dogs

Abstract. Litters of puppies were isolated, with the bitch, in fenced acre fields from 2 to 14 weeks of age. They were removed indoors at different ages, played with for a week, and returned to the field. The pups manifested an increasing tendency to withdraw from human beings after 5 weeks of age and unless socialization occurred before 14 weeks of age, withdrawal reactions from humans became so intense that normal relationships could not thereafter be established.

The term *imprinting* is generally defined as a capacity of some species of birds to develop a permanent attachment to any species, including man, made available to it during a critical period in its early development. This period of primary socialization usually ends with a mounting tendency to flee from strange species (*1*). The present experiment demonstrates a similar phenomenon in a mammalian species.

This study derived from the observation that purebred cocker spaniels exhibited intense flight responses to humans after they had been raised in an acre field with a minimum of human contact prior to 14 weeks of age. Our unsuccessful attempts to tame or socialize them led us to examine the age when human contact would most effectively reduce the withdrawal response at 14 weeks of age.

Five litters of cocker spaniels ($N = 18$) and three litters of beagles ($N = 16$) were raised in acre fields bounded by an 8-foot high wooden fence. The mother and her litter were raised alone in the pen and received food and water through drops in the fence. Pups from each litter were taken from the field for a week of socialization at 2 weeks of age ($N = 6$), 3 weeks, of age ($N = 6$), 5 weeks of age ($N = 7$), 7 weeks of age ($N = 7$), and 9 weeks of age ($N = 3$), and then returned to the field. During this week indoors, pups were played with, tested, and cared for throughout three daily half-hour periods (*2*). Controls remained in the field ($N = 5$) until the entire litter was taken indoors for final testing at 14 weeks of age.

At the start of the week of socialization pups removed from the field at 5 weeks of age scored significantly higher on a test of attraction to a handler [Handling Test (*3*)] than those removed at 2, 3, or 9 weeks of age ($p = 0.01$ to 0.05; t, tests). The low scores of 2- and 3-week-olds were due simply to their physical and motor immaturity, while 9-week-olds exhibited low scores because they had a marked tendency to avoid the handler. By the end of the week of socialization, however, all save the still immature 2-week-olds were equally attracted to the handler.

The progressive development of avoidance responses was evident in daily, 10-minute tests of the amount of time a puppy spent in physical contact with a passive, reclining human. Two-week-olds, again, were too immature to do much but sleep, eat, or crawl about randomly; 3-week-olds were immediately attracted to the experimenter and spent most of the 10-minute period pawing, mouthing, and biting him and his garments; 5-week-olds exhibited wariness at first, but they became comparable to 3-week-olds before the end of the first play period; 7-week-old pups, however, were frightened and wary of contacting the experimenter over the first *two* days of socialization, while 9-week-old pups exhibited these reactions over the first three days. No p values are given since this test was administered only to the last three litters; however, notes taken on all animals reveal no exceptions to this pattern of progressive avoidance, and it was persistently observed in the other situations of the socialization period.

After removal from the field at 14 weeks of age a series of tests was administered over a 2-week period. The handling test was administered to all pups at the start and at the end of this period of testing, a period involving daily contact with humans. At 14 weeks the pups socialized in their second week, and the controls scored significantly lower in "attraction to the handler" than did the fifth, seventh, and ninth week groups ($p \leqslant 0.05$, t tests). By the 16th week, however, only the control group remained significantly low, and it scored lower than all other groups ($p \leqslant 0.02$, t tests). These results are illustrated in Fig. 1.

Since the control animals appeared as timid on the final day of testing as

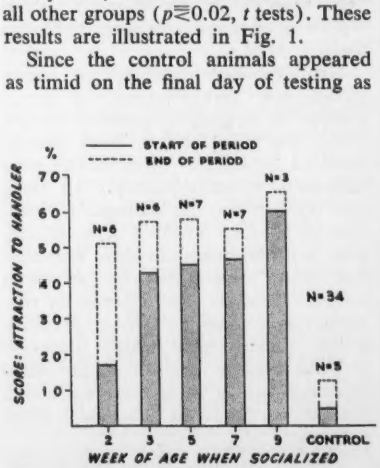

Fig. 1. Performance in the handling test. A measure of attraction to the handler, comparing performance at the start and at the end of the final period of testing (14 and 16 weeks of age).

Table 1. Rank order for tests administered after 14 weeks of age. (The higher numbers rank low.)

Test	Rank at age socialized					Controls
	2 wk	3 wk	5 wk	7 wk	9 wk	
			Handling			
Initial attraction to handler	5	4*	3*	2*	1*	6
			Leash control			
Eating in strange situation	4	3	1.5*	1.5*	5	6
Fewer balks	4	5	3*	1*	2*	6
			Reactivity test			
Total activity	2	4	3	1	6	5
Heart rate	6	3	4	1	2	5
Vocal, panting, and tail wagging	2	3	4	1	5	6

*Distinctly superior rank

on the first, one control animal, selected at random, was petted and fondled each day for a period of 3 months. The handling test was readministered at that time, and the animal showed only a slight positive change in score. It is our impression that any of the control pups would have been similarly resistant to socialization.

The leash-control test (*3*), devised to test an animal's resistance to training to a leash, was administered over a period of 10 days. There was significantly greater ease in the training of animals socialized at 5, 7, and 9 weeks of age than with the two younger groups and the controls ($p \leqq 0.01$, Wilcoxen rank test, and see Table 1). It appears that while socialization experiences during the second and third weeks of age were effective, as judged by the handling test, the stress conditions of leash training favored the scores of animals socialized during the fifth, seventh, or ninth week of age.

The final test was the reactivity test (*3*). Each pup was placed in a physiological harness and subjected to various stimuli such as cajoling and threat from a human, acoustic-startle, and electric shock. Heart rate, depth of respiration, and muscle tension were concurrently recorded in an electrocardiographic apparatus, while an observer made note of other aspects of the animal's reactions. This test appears to contrast ease of response (high score) with the tendency to "freeze" (low score). The controls were more inhibited than the seventh-week group on each of three subscores ($p = 0.05, 0.01, 0.01$, Mann-Whitney). In Table 1 we see that the seventh-week group ranked highest on all three subscores, indicating primacy in activity level, heart rate, vocal behavior, and tail wagging.

Although further work is necessary, the net results suggest that the seventh week of age was the period in which the pups were most receptive to socialization, and that 2½ to 9–13 weeks of age approximates a critical period for socialization to human beings. These figures are in accord with the findings of Pfaffenberger and Scott (*4*) and Scott and Marston (*5*). It is important to note that within this period motor and perceptual development reach maturity while, on the other hand, motivation to flee from strange species is not yet strong. We suspect that such a balance of factors is characteristic of a period that is critical for the formation of primary social relationships (*6*).

DANIEL G. FREEDMAN*
JOHN A. KING
ORVILLE ELLIOT†
Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine

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* Present address: Langley Porter Neuropsychiatric Institute, San Francisco, Calif.
† Present address: Department of Anthropology, Harvard University, Cambridge, Mass.

21 November 1960

Physiological Limits for "Subliminal" Perception

Abstract. Cortical, subcortical, and peripheral sensory nerve potentials were studied in cats to determine comparative thresholds of response. Stimuli capable of eliciting responses in peripheral nerve also invariably elicited responses from thalamus and cortex. Together with relevant data from human studies, the results indicate that stimuli subthreshold for perception do not affect the nervous system. They also have implications for studies of "subliminal" perception.

In recent years much investigative and popular interest has been directed toward the problem of "subliminal" perception. Such perception is said to occur when stimuli which are presumably below threshold, because they are not reported, nevertheless exert some influence upon behavior.

Although the psychological aspects of the problem have received careful scrutiny (*1*), little attention has been paid to physiological mechanisms which might mediate "subliminal" perception. Knowledge of such mechanisms could be crucial in clarifying the nature of the problem. For example, if it were known that stimuli of intensity lower than the sensory threshold can elicit brain responses, this would provide a definite physiological basis for "subliminal" perception. On the other hand, if it were shown that brain responses are produced only by stimuli at or above threshold, it would be clear that "subliminal" perception, in the strict meaning of the term, is not physiologically possible.

The probability that subthreshold stimuli do not produce brain responses has been suggested by three studies of cortical potentials evoked by sensory stimulation in man. Because the cortical potential evoked is not ordinarily visible in the scalp electroencephalogram, averaging methods were employed in these studies to bring out the responses. Shagass and Schwartz (*2*) found that the first evidence of cortical response to ulnar nerve stimulation coincided with the sensory threshold and that stimuli which were not perceived produced no response. Geisler, Frishkopf, and Rosenblith (*3*) obtained sim- Dawson (*4*) simultaneously recorded ilar results with auditory stimulation. cortical responses and action potentials in median and ulnar nerve and found no fibers in either nerve with thresholds lower than that for producing cortical responses. Taken together, the findings of these studies suggest that subthreshold sensory stimuli produce neither peripheral nerve responses nor cortical responses. However, because these investigations relied upon skin electrodes and averaging techniques, it seemed desirable to test this conclusion in a study employing direct recording methods.

In our experiments, simultaneous recordings were made from exposed cortex and either medial lemniscus, thalamus (ventral posterolateral nucleus), or peripheral nerve in the cat. In a total of 13 animals, cortex was compared with medial lemniscus in three cats, to ventral posterolateral nucleus in three, and to superficial radial nerve in ten. Stimulation was applied to superficial radial nerve by a Grass S4G stimulator through a Grass SIU4B isolation unit. Stimulus intensities were varied systematically in steps of 0.1 volt from low levels, producing no responses, to suprathreshold values. Re-

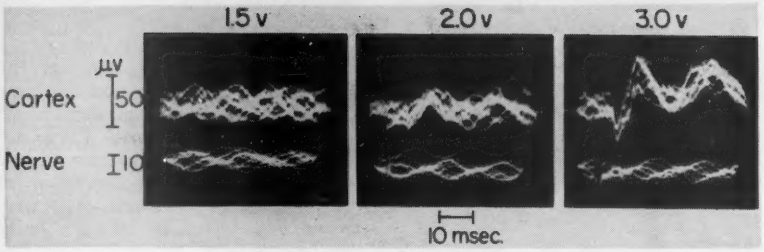

Fig. 1. Superficial radial nerve and cortical responses to varying intensities of stimulation (stimulus duration, 0.01 msec). Ten superimposed sweeps in each. At 1.5 volts only the stimulus artifact is recorded; at 2.0 volts a barely detectable response appears in the nerve while the cortical response is quite apparent; at 3.0 volts both responses are clear.

sponses were amplified by Tektronix type 122 preamplifiers, displayed on a Tektronix type 502 dual beam oscilloscope, and photographed with a Dumont Polaroid camera.

Four animals were studied in the unanesthetized state, after they had been prepared surgically under ether and then immobilized with gallamine triethiodide (Flaxedil) and placed under artificial respiration. The remaining animals were studied under light-to-moderate pentobarbital anesthesia. Cortical records were obtained from somatosensory areas I and II by means of monopolar wick or silver–silver chloride balls with the indifferent electrode on the cut edge of the scalp; depth electrodes were bipolar nichrome wires insulated except at the tips; nerve recordings were from either stainless steel bipolar needles inserted through the nerve or bipolar silver plates on which the nerve rested.

In all instances, stimuli capable of evoking responses either subcortically or in the peripheral nerve also elicited responses from the cortex. Figure 1 illustrates responses elicited by varying intensities of nerve stimulation in simultaneous recordings from superficial radial nerve and somatosensory I in an unanesthetized cat. It can be seen that when stimulation results in peripheral responses, responses are also evoked in the cortex. Identical results were obtained in all animals, anesthetized and unanesthetized. These results are in accord with those of Mark and Steiner (*5*) on deeply anesthetized cats.

The data of Shagass and Schwartz (*2*) indicate that a necessary, though not sufficient, condition for the occurrence of human perception is the elicitation of responses at the cortex. Obviously responses cannot be elicited from the cortex by a stimulus which has not excited the peripheral nerve. Present results and those of Dawson (*4*) indicate, however, that there are no responses peripherally or subcortically without the concurrent evocation of responses in the cortex.

In view of these results, it would appear that the term "*subliminal perception*" is a misnomer in regard to those experiments in which stimuli below threshold for perception are applied (for example, *6*). If these stimuli are truly subliminal, perception *cannot* occur. They have no effect on the nervous system. Those experiments on "subliminal" perception which do employ stimuli capable of producing nervous system responses would seem to be dealing mainly with the relationship between perception and attention. These stimuli may or may not be immediately perceived, depending upon factors, such as distraction, which influence "focus of attention." The experiments of Hernández-Peón *et al.* (*7*) demonstrate a neurophysiological correlate of fluctuations of perception under different conditions of attentiveness. In these experiments evoked sensory potentials diminished when a different and more attention-getting stimulus was concurrently introduced. However, it should be clearly recognized that, although no longer attended to, these stimuli were not subliminal (*8*).

MARVIN SCHWARTZ
CHARLES SHAGASS

Department of Psychiatry, Psychopathic Hospital, State University of Iowa, Iowa City

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14 December 1960

Cellular Adaptation to Morphine in Rats

Abstract. The respiration of KCl-stimulated cortical slices of brain from control rats is markedly depressed by morphine, whereas the respiration of those from rats chronically dosed with morphine is unaffected. The results demonstrate an adaptation to morphine at the cellular level which is concomitant with the adaptation of the whole animal to morphine.

The stimulatory effect of 0.1*M* potassium chloride on the oxidation of cortical slices from the brain in the presence of glucose is well established. Since the original observation of this effect by Ashford and Dixon (*1*), several workers have studied the effect of depressant agents such as various barbiturates (*2, 3*), hypnotics (*2, 3*), and ethanol (*3, 4*) on the oxidation of KCl-stimulated cortical slices. These authors found a marked depression of the oxidation of stimulated slices with depressant agents at concentrations which are relatively ineffectual, or even stimulatory in the case of ethanol, on the oxidation of unstimulated slices. Studies were never made on cortical slices of brain obtained from an animal chronically treated with depressant agents.

Male Holtzman rats, weighing 200 to 300 g, were chronically morphinized intraperitoneally with an initial dose of 15 mg/kg twice daily, which was increased in 15-mg/kg increments weekly

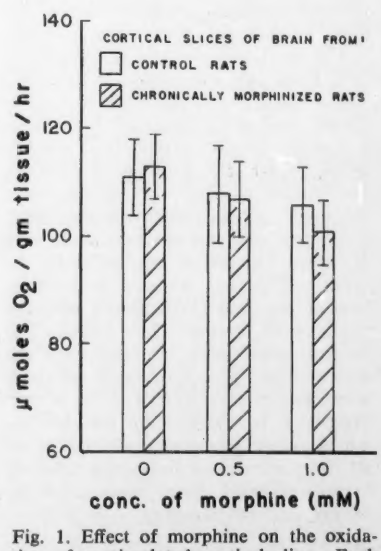

Fig. 1. Effect of morphine on the oxidation of unstimulated cortical slices. Each bar represents an average of 15 rats. The vertical lines at the top of each bar show the standard error. None of the groups are significantly different ($p > 0.2$) from their respective control groups (no morphine).

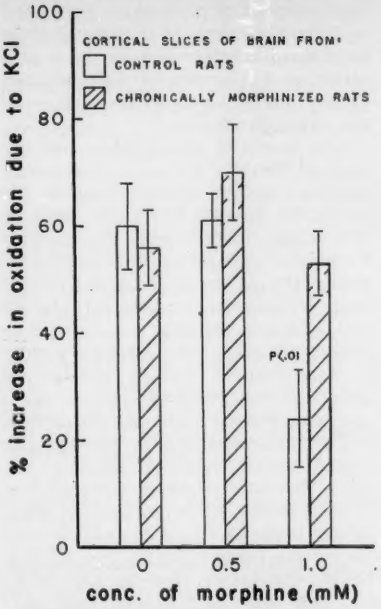

Fig. 2. Effect of morphine on the stimulated oxidation of cortical slices. Each bar represents an average of 15 rats. The vertical lines at the top of each bar show the standard error. Only one group, as indicated ($p < 0.01$), is significantly different from the control group (no morphine).

for 3 weeks until the rats were receiving 45 mg/kg twice daily during the third week. The rats became tolerant to the depressant and analgesic effects of morphine during this treatment. Control animals received isotonic saline injections throughout the course of the experiment. Eighteen hours after the last dose, the rats were decapitated and cortical slices of their brains were prepared for analysis.

Respiration was measured manometrically by the conventional Warburg technique at 37°C with oxygen as the gas phase. The incubating medium contained 0.135*M* NaCl, 0.005*M* KCl, 0.0013*M* $MgSO_4$, 0.0005*M* $CaCl_2$, 0.012*M* glucose, and 0.01*M* KH_2PO_4–Na_2HPO_4 buffer, *p*H 7.4. After readings were taken every 10 minutes for 40 minutes, KCl (0.1*M*) or various concentrations of morphine or both were tipped from the side arm into the main compartment, and readings were taken for an additional 50 minutes at 10-minute intervals. There was a 10-minute lag period before the effect of KCl became fully apparent and before the rate again became linear.

At concentrations of 5×10^{-4} and 1×10^{-3} *M* morphine does not affect the oxidation of unstimulated cortical slices from control or chronically morphinized rats (Fig. 1). This agrees with other reports (*5*) that morphine is without effect at concentrations as high as $3.2 \times 10^{-5}M$ and 0.01*M*. Potassium chloride stimulates the oxidation of slices from both control and chronically morphinized rats to about 60 percent above the unstimulated rate in the absence of morphine (Fig. 2). The respiratory stimulation of slices from control rats is only about 24 percent in the presence of $1 \times 10^{-3}M$ morphine, while the respiratory stimulation of slices from morphinized rats remains unaffected. At a concentration of $5 \times 10^{-4}M$ morphine appears to have no significant effect on the stimulated slices from either control or chronically morphinized rats. The results show an adaptation to morphine at the cellular level. This adaptation occurs at a time when the whole animal is pharmacologically adapted to the effects of morphine.

Eddy (*6*) pointed out that among the numerous explanations offered for the phenomenon of tolerance to narcotic analgesics, increased biotransformation of the drug and cellular adaptation have the greatest likelihood for clarifying this problem. The metabolism of morphine in tolerant animals appears to be unrelated to the development of tolerance (*7*). In fact, enzymic studies show less *N*-demethylating capacity (*8*) and less transferase activity (*9*) in livers obtained from tolerant rats than in livers obtained from nontolerant rats. Cellular adaptation is an attractive explanation for the formation of tolerance, but supporting evidence for this hypothesis is meager.

Although the in vitro concentration of morphine employed in this study is still quite high compared to the theoretical in vivo concentration of morphine in the central nervous system, the demonstration of a definite difference between the tissues from control and chronically morphinized rats in resisting the depressive effect of morphine offers a promising tool for studying cellular adaptation in vitro (*10*).

A. E. TAKEMORI

Department of Pharmacology, State University of New York, Upstate Medical Center, Syracuse

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30 November 1960

Stability of Protein in Intestinal Epithelial Cells

Abstract. In vivo measurements have revealed a high degree of stability of synthesized protein in rapidly proliferating intestinal epithelial cells. A slow loss of protein has been found during migration of mature cells to the villus tip.

Although previous studies have provided support for the concept of "dynamic equilibrium" of proteins in mammalian cells (*1*), the occurrence of rapid intracellular protein degradation and turnover has recently been questioned (*2*). In bacteria, several studies (*2, 3*) have indicated that protein, once synthesized, is stable. The rates of protein degradation here were so low that dynamic intracellular protein turnover was not believed to play a role in protein synthesis in these cells. Recently, similar evidence was found in mammalian cells of the L strain grown in tissue culture (*4*). In addition, although protein breakdown was found in resting yeast cells, a much smaller rate of degradation was present in dividing cells (*5*). The results of the present studies, performed in vivo, suggest that visceral parenchymal cells which are renewed rapidly maintain a high degree of stability of synthesized proteins with little degradation, while protein breakdown or loss is greater in the older nonproliferating cells derived therefrom.

The incorporation of labeled leucine into proteins of the jejunum was measured. Adult C57 Brown mice were maintained on a standard nutritional diet. Microautoradiographic measurements were made of the cells of the proximal jejunum removed after intraperitoneal injection of 100 μc of tritiated leucine (specific activity, 370 mc/mmole). Chromatographic analysis of injected material revealed no free label. In addition, the tissues were washed with solutions containing trichloracetic acid, and chemical analysis revealed no free amino acid present, indicating that most grains activated

were due to tritium incorporated into protein.

For the microautoradiographic studies, slides carrying sections of labeled material were dipped into liquid emulsion (NTB), exposed for 1 to 2 weeks at 4°C, developed, stained, and examined. Since the electrons produced in the decay of tritium have a range in tissue of about one μ, activated silver grains tend to be closely apposed to the structures labeled. It was therefore possible to identify sites of incorporation of tritiated leucine with a resolution of a fraction of a cell size.

Quantitative estimates of relative rates of leucine incorporation were based on counts of grain density over various kinds of cells, and various portions of cells. Since the sections were cut 5 μ thick, that is, infinitely thick compared to the range of tritium beta rays, these counts are proportional to the amount of tritium incorporated. Exposure time was identical in all experiments.

The findings were as follows: Grain counts were highest about 2 to 4 hours after injection. This corresponded to the maximum height of specific activity curves of labeled leucine incorporated into mucosal protein precipitate, measured in a separate series of radiochemical studies. In the microautoradiographs, incorporation at 2 to 4 hours was higher in the epithelial cells than in smooth muscle cells and fibroblasts. The epithelial cells in the crypts were more heavily labeled than those on the villi. On the villus a definite gradient was also observed, with the cells near the base being more heavily labeled than those near the tip. Within the epithelial cells label was most heavy near the surface; this was more pronounced in villus cells than in crypt cells. Nuclei were less heavily labeled than cytoplasm, particularly on the villi.

In the jejunum, epithelial cell production is restricted to the crypts. The majority of epithelial cells in the crypts are proliferating, a smaller fraction are in process of differentiation, and still fewer are fully mature. Villus cells are in steady migration from the mouths of the crypts to the tips of the villi, from where they are sloughed off into the lumen. During this phase of migration, they do not proliferate; however, they differentiate further, and microvilli grow rapidly as cells migrate from the villus base to the tips.

The concentration of label near the surface of villus epithelial cells appears to be due to protein synthesis or accumulation of protein in or near rapidly growing microvilli. The heavy concentration of label in crypt epithelial cells indicates rapid protein synthesis in the proliferating cells. The microvilli do not grow rapidly in crypt cells and those cells do not show heavy labeling near the surface.

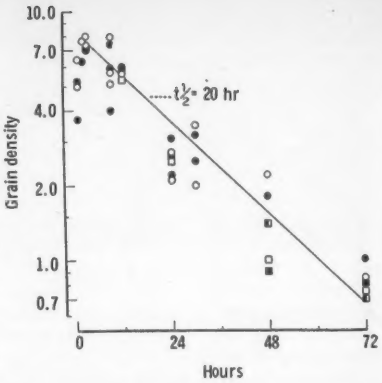

Fig. 1. Grain densities (grains per 64 μ^2 per 100 μc per week exposure) over jejunal crypt epithelial cells, plotted against time. Each point represents one animal. The circles and squares indicate separate experiments. Empty symbols, cytoplasm; full symbols, nuclei.

Studies of microautoradiographs of animals sacrificed up to 3 days after labeling yielded the data shown in Figs. 1 and 2. In the *crypts* (Fig. 1) the grain density is about the same over nuclei and cytoplasm; it reaches a peak shortly after labeling and then declines roughly exponentially with a half-life of about 20 hours. This is precisely what should result if there is no intracellular degradation and loss of protein in these proliferating cells. They have been shown to divide approximately every 19 hours (*6*). At each division, the labeled protein is diluted to one-half by production of new unlabeled protein, each daughter cell receiving roughly equal amounts of labeled and unlabeled protein. The data, however, are not precise enough to exclude a minor loss of labeled protein.

Separate studies have shown that, within about 1¾ days after labeling, the cells which occupied the *base of the villi* at the time of injection have been replaced by cells which have come up from the crypts (*6*). Some of these have divided before leaving the crypts; others, in the process of differentiation at the time of labeling, have left without previous division.

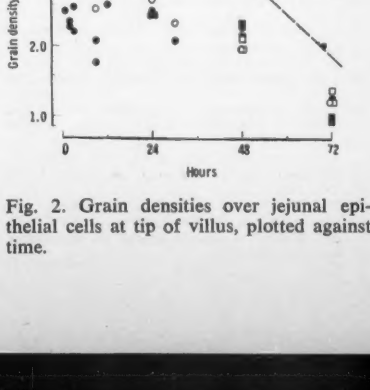

Fig. 2. Grain densities over jejunal epithelial cells at tip of villus, plotted against time.

The results of counts taken over the base of the villi up to 12 hours after labeling showed heavier label in the cytoplasm (about 5.6 units) than in the nuclei (about 4.2). In preparations taken one or more days after labeling, this difference disappeared. The peak grain count, reached between 12 and 24 hours, was near 5.5. From 1 to 3 days, the grain count declined roughly exponentially with a half-life of about 20 hours. These changes again can be accounted for by cell movement.

The cells which pass through the base of the villi reach the region of the *tip* 1 day later. If there were no loss of label during this migration, the grain counts over the tip of the villi should follow the dashed line in Fig. 2. Actually, the values obtained 30 hours and later after labeling are about one-half less. This indicates that during the migration about one-half the label was lost.

In these experiments there was, therefore, no evidence of major intracellular loss of protein, or turnover, in proliferating intestinal epithelial cells. There was, however, evidence of a moderate degree of protein loss in the mature cells derived from them. The same experiments revealed rapid loss of label over Paneth and pancreatic acinar cells, presumably due to secretory processes. It is not known how much of the protein lost from mature intestinal epithelial cells is accounted for by secretion of intact protein from the cells, or from loss of protein molecules that have undergone intracellular degradation. It may well be that, in the mature cell, protein contained in the vesicular endoplasmic reticulum of the proliferative cell undergoes degradation and possibly is partly reutilized in forming the tubular endoplasmic reticulum of the mature cell as well as enzymes and microvilli. Leblond *et al.*, in following S^{35}-labeled methionine incorporated into the epithelial cells of the duodenum of the rat, found that intensely labeled cells at the base of the villi moved to the tip (*7*).

The findings reported here indicate that protein in the proliferating epithelial cells of the jejunum is either highly stable or, if broken down, is reutilized not only in the same cell but even in the same fraction of the cell. The latter hypothesis appears less reasonable. It is, therefore, proposed that, in the rapidly growing cells of the intestinal epithelium, synthesized protein is suf-

ficiently stable to last through the proliferative cycle of the cells, and intracellular degradation or protein turnover does not have a significant role in fixing the net rate of protein synthesis or in contributing appreciably to the composition and protein structure of the proliferating cells (*8*).

M. LIPKIN
T. P. ALMY
H. QUASTLER
Department of Medicine, Cornell University Medical College, 2nd (Cornell) Medical Division, Bellevue Hospital, New York, and *Department of Biology, Brookhaven National Laboratory, Upton, New York*

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9 February 1961

Immunization as a Factor Affecting the Course of Septicemic Anthrax

Abstract. Immunization of guinea pigs with alum-precipitated antigen increased resistance approximately 1600 times. The growth rate of *Bacillus anthracis*, in the septicemic phase, was the same in both normal and immunized animals; however, the number of bacilli per milliliter of blood at death was decreased by 75 percent in immunized animals. Neither the enhancement of virulence by treatment with egg yolk nor the size of the challenge dose affected the growth rate or the number of bacilli per milliliter of blood at death. Mean time to death for the treatments tested varied from approximately 20 to 100 hours. Nonimmunized animals challenged with a strain of low virulence had a terminal number of bacilli per milliliter of blood and a growth rate in the blood the same as that for the highly virulent strain.

Anthrax is typified by an extremely rapid progress of disease, with symptoms and septicemia occurring some few hours before death of the animal. Bloom *et al.* (*1*) and Keppie *et al.* (*2*) state that the number of organisms per milliliter of blood appeared to be lower in partially immunized guinea pigs than in nonimmunized animals. This paper presents quantitative data regarding the in vivo rate of growth and the level of bacilli in the blood of immunized and normal guinea pigs during the septicemic stage of anthrax and notes the constancy of these observations regardless of certain treatment variations of the initial challenge dose.

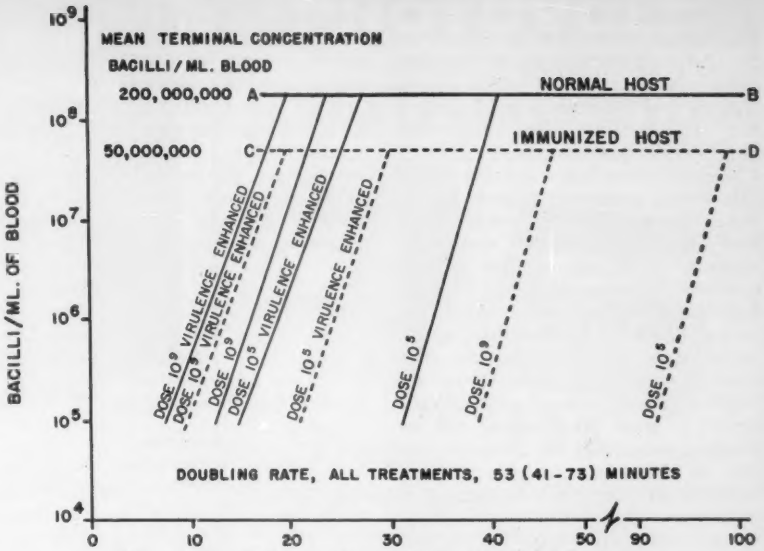

Fig. 1. Time, in hours, after challenge with virulent spores.

An experiment of four factors each at two levels was designed to investigate the septicemic phase of anthrax. These factors were host (immune or nonimmune), virulence (high or low), virulence-enhancement (enhanced or normal), and dose (10^8 or 10^5 spores); however, only the high dose level of the low virulent strain was used, because the low dose did not kill the host. Hartley strain guinea pigs, weighing 250 to 300 g, raised by the Fort Detrick animal farm were immunized by administration of 0.1 ml of a 1:10 dilution of antigen (*3*) given by intraperitoneal injection on days 1, 3, 5, 8, and 11. The animals were challenged on the 21st day with spores of either the virulent V1b strain or the low virulent 30R strain, a mutant of V1b. The immunity attained by this procedure, when the animals were challenged with spores of the virulent V1b strain, was approximately 1600-fold, that is, equal responses of immunized and control hosts were obtained by increasing the challenge dose of immunized animals 1600-fold. Virulence was enhanced by the addition of egg yolk medium to the inoculum (*4*). The measurement of virulence was based on a graded response method (*5*). After two initial experiments to establish techniques, groups of four immunized and two control animals were challenged with each of the treatment combinations, and tests were replicated on three occasions. The number of cells in the blood was determined quantitatively both by direct observation of stained slides, by the methods of Keppie *et al.* (*2*), and by a plate count assay method. The concentration of bacilli per milliliter of blood at the time of death is known as the terminal concentration. The factorial design was used to gain efficiency in regard to number of animals required for significant conclusions.

Data reported in a schematic graph (Fig. 1) are quantitative counts of bacilli observed on stained slides. For all treatment conditions the growth of bacilli in the blood, observed during approximately the 12 hours preceding death, was exponential, and all growth curves were parallel as shown in Fig. 1. The doubling rate of bacilli in the blood (apparent generation time) averaged 53 minutes (41 to 73 minutes for 95 percent confidence limit). The number of bacilli per milliliter of blood in the normal animals was constant for all treatment conditions (line *AB*, Fig. 1) and approximately four-fold higher than the average number found in the immunized host (line *CD*, Fig. 1). This difference is statistically significant and is based on 23 immunized and 15 control guinea pigs. Survival time in normal guinea pigs is considerably shorter than in immunized guinea pigs. Response of animals challenged with the 30R strain of low virulence was only partial; therefore, data on these

variables are incomplete. However, the constants of apparent generation time and terminal concentration appear to be equivalent to that observed with the virulent V1b strain, although it is noted that most of the animals responding to the 30R challenge were those challenged with virulence-enhanced spores.

Thus it is concluded that the growth rate in the septicemic stage is not affected by specific host resistance, by dose level (or, alternately, time of response), or by enhancement of virulence by treatment of spores with egg yolk, a treatment that in these tests gave a 120-fold increased virulence for guinea pigs. We conclude, also, that immunization significantly lowers the number of cells present in the blood stream at death when normal and immunized guinea pigs are compared, and that the disease caused by a strain of low virulence, once it is established as septicemic anthrax, is or may be equally as severe and dangerous as that caused by the highly virulent strain.

There is no evidence from these data that the host defenses are overpowered or change during the period of septicemic growth—otherwise the response slopes would not be linear. Growth, as indicated by increased cell number during this final stage of the disease, may be compared favorably with the growth rate in the logarithmic growth phase of culture in vitro in media such as tryptose or nutrient broth. Since the terminal concentration of bacilli per milliliter of blood is significantly lower in immunized animals than in nonimmunized hosts, it follows that, if these data are translatable to other animals, treatment will need to be initiated while the number of bacilli per milliliter of blood is much lower in the immunized than in the nonimmunized hosts. The critical level of organisms per milliliter of blood in the guinea pigs was reported by Keppie *et al.* (*2*) to be 1/300th of the terminal concentration, and after this no effective antibiotic cure can be predicted.

Since death by anthrax has been ascribed to a toxemia (*6*), and since toxin has been detected both in vivo and in vitro, our observations raise questions regarding the critical number of organisms per milliliter of blood in relationship to toxin produced in immunized as compared to normal animals. It is possible, since immunization prolongs the time from dose to septicemia, that more organisms and more toxin are produced before septicemia is detected, and therefore the animal dies with a lower level of organisms per milliliter of blood.

FREDERICK KLEIN
BILL G. MAHLANDT
RALPH E. LINCOLN
IRA A. DEARMON, JR.
ALBERT L. FERNELIUS
U.S. Army Chemical Corps, Fort Detrick, Frederick, Maryland

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9 August 1960

Growth of Sporangiophores of Phycomyces Immersed in Water

Abstract. Sporangiophores of *Phycomyces* are capable of sustained growth when immersed in aerated water, and under these conditions they are negatively phototropic.

When immersed in water saturated with air at atmospheric pressure, sporangiophores will grow for many hours at the rate of 1.5 mm/hr. This rate is equal to one-half the growth rate in air (*1*). The reduction of the growth rate is not due to lack of oxygen in the ambient water, because increasing the oxygen tension in the water by (i) saturating the water with pure oxygen or by (ii) saturating the water at 0°C with pure oxygen, warming slowly to 22°C under 4 atm pressure of pure oxygen, and maintaining this increased pressure throughout the test has no effect on the growth rate. In air, if the oxygen tension is raised above 20 percent, there is no change in the growth rate of the plant (*2*). It appears then, that when the rate of oxygen supply is not limiting, 1.5 mm/hr is the growth rate in water, in contrast to 3.0 mm/hr in air. In either case, there is probably no significant oxygen gradient at the cell wall.

I have attempted to measure the oxygen consumption of the growing zone by Warburg manometric techniques, but have succeeded only in establishing an upper limit of about 0.5 mm^3/hr.

Specimens growing in water exhibit *negative* phototropic reactions. This may seem surprising in view of the fact that the refractive index of water (1.33) is slightly below that of the cell contents (1.35), and Buder's theory (*3*) would therefore predict a positive reaction. However, it may be presumed that internal absorption, estimated to be 10 percent by Delbrück and Shropshire (*4*), is sufficient to overcompensate the slight residual lens effect.

The possibility of growing specimens in aerated water opens the way to testing the effects of any water-soluble substrates or inhibitors on growth and reactivity. I have tested a number of enzymatic inhibitors but have not found any that would discriminate between growth and photoreactivity (*5*).

RICHARD BOND STIFLER*
California Institute of Technology, Pasadena

References and Notes

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2. C. Hamilton, personal communication.
3. J. Buder, *Ber. deut. botan. Ges.* **36**, 104 (1918).
4. M. Delbrück and W. Shropshire, Jr., *Plant Physiol.* **35**, 194 (1960).
5. I would like to thank Dr. Max Delbrück for suggesting this work, and for subsequent discussions pertaining to it. The work was sponsored by a National Science Foundation Undergraduate Research Grant.
* Present address: Department of Biology, Massachusetts Institute of Technology, Cambridge.

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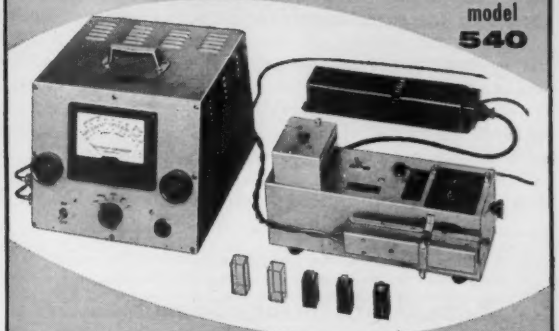

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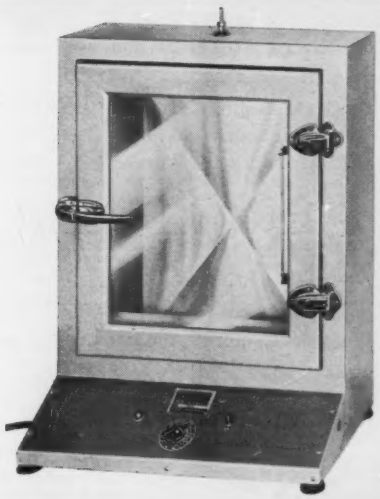

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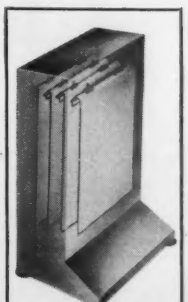

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Meetings

Entomology and Human Welfare

Frank S. Arant, head of the department of zoology and entomology, Alabama Polytechnic Institute, has been chosen by the governing board of the Entomological Society of America as the society's president for 1961. Acceptance of a foreign assignment by H. M. Harris, of Iowa, president-elect in 1960, led to his resignation and the selection of a president by board action rather than by ballot of the membership. Robert Glen, director, General Research Branch, Canada Department of Agriculture, Ottawa, is president-elect for 1961.

The 1960 Atlantic City meeting of the Society, held 28 November through 1 December, drew a larger attendance (859) than any previous meeting of the society other than joint meetings with Canadian societies. The theme of the meeting was, "Entomological Contributions to Human Welfare."

M. P. Jones, entomologist with the extension service of the U.S. Department of Agriculture, the society's president for 1960, delivered the presidential address, "Selling insect control information." The John Henry Comstock memorial lecture, "The challenge of insecticide resistance," was delivered by A. W. A. Brown of the University of Western Ontario. J. George Harrar, vice president of the Rockefeller Foundation, addressed a plenary session on food additives and public health.

Dionyz Blaskovic, director of the Institute of Virology, Blatislava, Czechoslovakia, and K. C. Willett, director of the West African Institute for Trypanosomiasis Research, Kaduna, Northern Nigeria, were participants in a symposium on biological transmission of disease agents. The Rockefeller Foundation made possible the attendance of these two speakers.

Lester G. MacNamara, chief of the New Jersey Bureau of Wildlife Management, also addressed an evening plenary session, on the role of chemicals in wildlife conservation.

There were 186 submitted papers, 14 symposia and panel discussions, and 19 invited speakers; the program was arranged by Ralph W. Sherman, U.S. Department of Agriculture, program chairman. L. G. Merrill, Jr., of Rutgers University, was chairman of the local arrangements committee.

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Forthcoming Events

April

23–27. Society of American Bacteriologists, Chicago, Ill. (E. M. Foster, 311 Bacteriology, Univ. of Wisconsin, Madison)

23–28. American Soc. of Hospital Pharmacists, Chicago, Ill. (J. A. Oddis, 2215 Constitution Ave., NW, Washington 7, D.C.)

24–26. Aerospace Medical Assoc., 32nd annual, Chicago, Ill. (W. J. Kennard, Secretary-Treasurer, c/o Washington National Airport, Washington, D.C.)

24–26. American Psychoanalytic Assoc., annual, Philadelphia, Pa. (J. N. McVeigh, 36 W. 44 St., New York 36)

24–26. International Acad. of Pathology, 50th annual, Chicago, Ill. (Miss M. Davis, Intersociety Committee on Pathology Information, 1785 Massachusetts Ave., NW, Washington 6, D.C.)

24–27. American Assoc. of Petroleum Geologists, Denver, Colo. (G. V. Cohee, U.S. Geological Survey, Washington 25, D.C.)

24–27. American Physical Soc., Washington, D.C. (K. K. Darrow, 538 W. 120 St., New York 27)

25–28. Society of Economic Paleontologists and Mineralogists, Denver, Colo. (J. Imbrie, Dept. of Geology, Columbia Univ., New York, N.Y.)

26–28. American Assoc. of Pathologists and Bacteriologists, 58th annual, Chicago, Ill. (Miss M. Davis, Intersociety Committee on Pathology Information, 1785 Massachusetts Ave., NW, Washington 6, D.C.)

27–28. Diseases in Nature Transmissible

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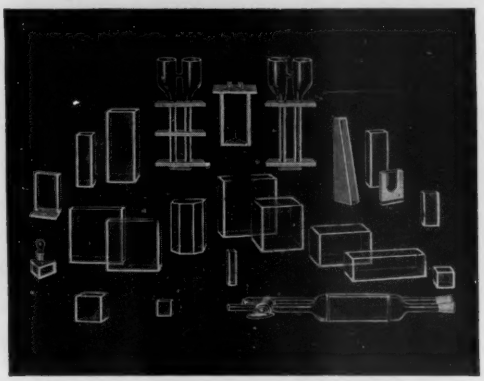

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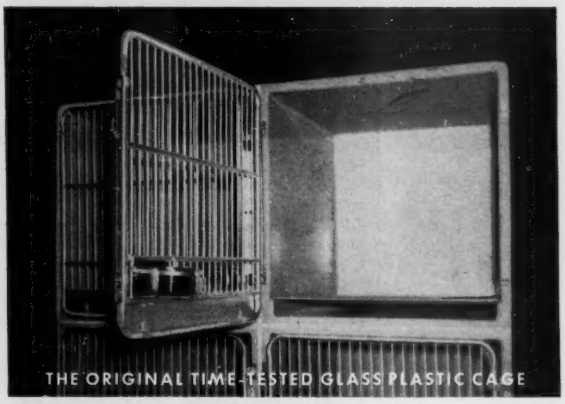

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REFERENCES:

1. O. Bodansky, Cancer, 7, 1191, (1954).
2. O. Bodansky, Cancer, 8, 1087, (1955).
3. Bruns & Hinsberg, Biochim. Ztschr., 325, 532, (1954).
4. Taylor & Friedman, Clin. Chem., 6, 208, (1960).
5. Sterkel, etal., J. Lab. & Clin. Med., 52, 176, (1958).

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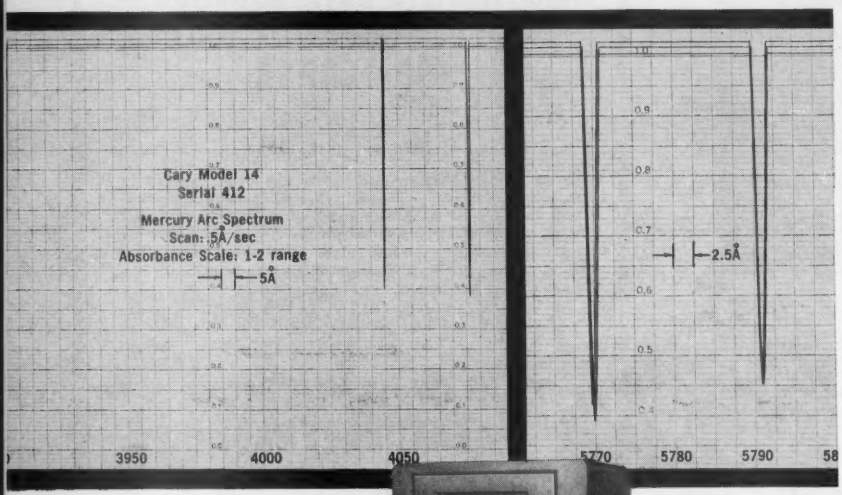

FIGURE 1

FIGURE 2

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27–28. Health Education Conf., New York Acad. of Medicine, New York, N.Y. (I. Goldston, 2 E. 103 St., New York 29)

27–29. American Acad. of Neurology (members and guests), Detroit, Mich. (Mrs. J. C. McKinley, 4307 E. 50 St., Minneapolis 17, Minn.)

27–29. Wildflower Pilgrimage, 11th annual, Great Smoky Mountains Natl. Park, Tenn. (A. J. Sharp, Dept. of Botany, Univ. of Tennessee, Knoxville)

27–30. Congress of Laboratory Medicine, Berlin. (W. Massmann, Rubensstr. 125, Berlin-Friedenau, Germany)

27–5. American Psychiatric Assoc., annual, Philadelphia, Pa. (D. Blain, 1700 18 St., NW, Washington 6)

28–30. American Psychosomatic Soc., 18th annual, Atlantic City, N.J. (M. F. Reiser, 265 Nassau Road, Roosevelt, N.Y.)

30–4. Aero/Space Instrumentation Symp., 7th annual, Dallas, Tex. (W. J. Gabriel, Route 3, Box 36, Fort Worth, Tex.)

30–4. Electrochemical Soc., Indianapolis, Ind. (R. K. Shannon, 1860 Broadway, New York 23)

30–6. Conference on Internal Medicine, Nassau, Bahamas. (Bahamas Conferences, P.O. Box 1454, Nassau)

May

1–3. American Oil Chemists' Soc., St. Louis, Mo. (K. F. Mattil, Swift and Co., U.S. Yards, Chicago 9, Ill.)

2–3. American Pediatric Soc., Atlantic City, N.J. (C. M. Riley, Denver General Hospital, Denver 4, Colo.)

2–3. Association of American Physicians, Atlantic City, N.J. (P. B. Beeson, Yale Univ. School of Medicine, New Haven 11, Conn.)

2–5. Criticality Control in Chemical and Metallurgical Plant, intern. symp., OEEC, Karlsruhe, Germany. (European Nuclear Energy Agency, 38, Boulevard Suchet, Paris 16, France)

2–6. American Assoc. on Mental Deficiency, Cincinnati, Ohio. (N. A. Dayton, Mansfield Training School, Mansfield Depot, Conn.)

3–5. Nuclear Applications in Space Conf., Gatlinburg, Tenn. (J. J. Harford, American Rocket Soc., 500 Fifth Ave., New York, N.Y.)

3–6. American Goiter Assoc., Philadelphia, Pa. (J. C. McClintock, 702 Madison Ave., Albany 8, N.Y.)

3–6. Midwestern Psychological Assoc., Chicago, Ill. (I. E. Farber, Dept. of Psychology, State Univ. of Iowa, Iowa City)

3–7. Student American Medical Assoc., Chicago, Ill. (R. F. Staudacher, 430 N. Michigan Ave., Chicago 11)

4–5. Human Factors in Electronics, 2nd natl. symp., Arlington, Va. (H. P. Birmingham, Human Engineering Development Section, U.S. Naval Research Laboratory, Washington 25)

4–5. Society for Pediatric Research, Atlantic City, N.J. (C. D. West, Children's Hospital, Cincinnati 29, Ohio)

4–6. American Ethnological Soc., Co-

lumbus, Ohio. (Miss N. F. S. Woodbury, Arizona State Museum, Univ. of Arizona, Tucson)

4–6. American Philosophical Assoc., western division, St. Louis, Mo. (L. E. Hahn, Washington Univ., St. Louis 30, Mo.)

4–6. American Soc. of Human Genetics, Atlantic City, N.J. (W. J. Schull, 1133 E. Catherine St., Ann Arbor, Mich.)

4–6. New York State Psychological Assoc., annual, Rochester. (H. P. Iker, Strong Memorial Hospital, Room R-201, 260 Crittenden Blvd., Rochester 20)

4–6. Pediatric Surgery, symp., New York, N.Y. (Office of the Associate Dean, New York Univ. Post-Graduate Medical School, 550 First Ave., New York 16)

4–6. Society for American Archaeology, Columbus, Ohio. (J. B. Wheat, Univ. of Colorado Museum, Boulder)

4–7. Hypertension Symp. (by Hahnemann Medical College), Philadelphia, Pa. (Hahnemann Medical College and Hospital, 235 N. 15 St., Philadelphia 2)

5–6. Population Assoc. of America, New York, N.Y. (K. B. Mayer, Dept. of Sociology and Anthropology, Brown Univ., Providence 12, R.I.)

5–7. American Soc. of Internal Medicine, Miami Beach, Fla. (G. T. Bates, 350 Post St., San Francisco 8, Calif.)

5–8. American Psychoanalytic Assoc., Chicago, Ill. (Mrs. H. Fischer, 1 E. 57 St., New York 22)

6–7. Academy of Psychoanalysis, annual, Chicago, Ill. (J. H. Merin, 49 E. 78 St., New York 21)

6–9. Circuit Theory, 5th midwestern symp., Urbana, Ill. (M. E. Van Valkenburg, Dept. of Electrical Engineering, Univ. of Illinois, Urbana)

7–10. American Inst. of Chemical Engineers, Cleveland, Ohio. (J. F. Van Antwerpen, ALChE, 25 W. 45 St., New York 36)

7–11. Institute of Food Technologists, New York, N.Y. (C. S. Lawrence, 176 W. Adams St., Chicago 3, Ill.)

7–12. Medical Library Assoc., Inc., Seattle, Wash. (Miss R. J. Mann, Mayo Clinic Library, Rochester, Minn.)

7–12. Society of American Bacteriologists, 62nd annual, Kansas City, Mo. (E. M. Foster, 311 Bacteriology, Univ. of Wisconsin, Madison 6)

7–12. Society of Motion Picture and Television Engineers, Toronto, Canada. (SMPTE, 55 W. 42 St., New York 36)

8–9. Titrimetric Methods of Analysis, symp., Cornwall, Ontario, Canada. [J. R. McCallum, Courtaulds (Canada) Ltd., Cornwall]

8–10. Aerospace Electronics Conf., 13th annual natl., Dayton, Ohio. (R. G. Stimmel, Institute of Radio Engineers, 1 E. 79 St., New York 21)

8–10. Instrument Soc. of America, Power Instrumentation Symp., 4th natl., Chicago, Ill. (H. A. Van Wassen, Duquesne Light Co., Pittsburgh 19, Pa.)

8–10. Mathematical Theories of Biological Phenomena, symp., New York, N.Y. (N. Rashevsky, Committee on Mathematical Biology, 5741 Drexel Ave., Chicago 37, Ill.)

8–12. American College of Physicians, 42nd annual, Miami Beach, Fla. (ACP, 4200 Pine St., Philadelphia 4, Pa.)

(See issue of 17 February for comprehensive list)

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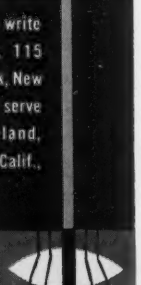

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POSITIONS WANTED

(a) **Young Biochemist Ph.D.**, bacteriology minor; radioisotope training; bacterial physiology, antibiotic resistance research and chemistry teaching experience; available for academic appointment. (b) **Animal Physiology** Ph.D June 1961; interested in behavior and reproductive research; desires academic or research position. (Please write for information regarding these and other scientists in all fields; nationwide service.) S3-5 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago. X

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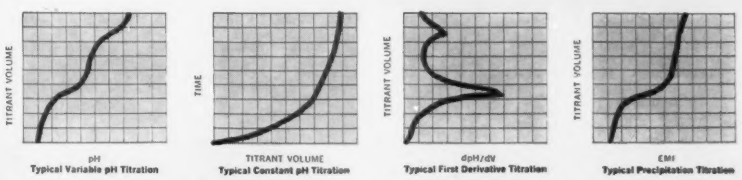

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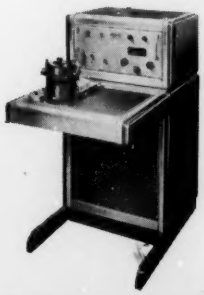

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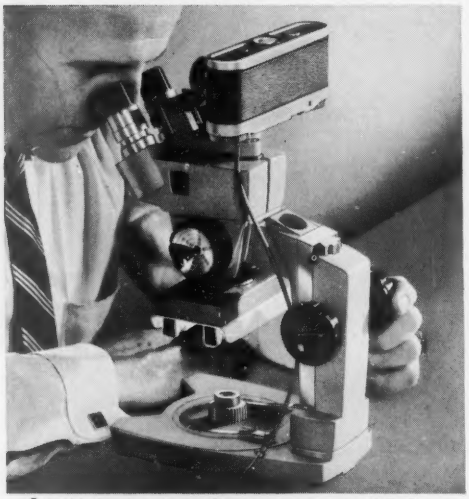

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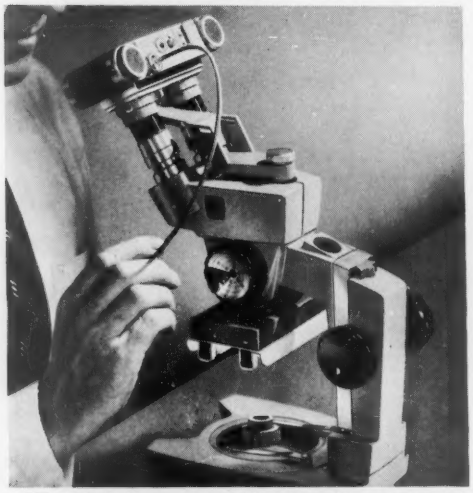

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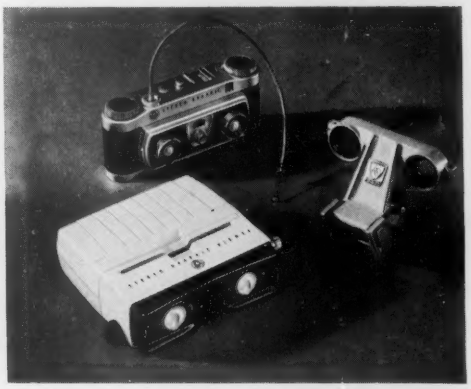

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